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# HABITABILITY SYSTEM ENVIRONMENTAL REQUIREMENTS AND DESIGN GUIDELINES FOR GROUP STABILITY

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16. Abstract

Guidelines and recommendations for habitability design are formulated to facilitate individual and group stability. These findings are based on reviews of previous studies involving persons in various terrestrial environments. Considerations were given to the NASA group model and properties of such a group.

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# ABSTRACT


This study defines the basic habitability system environmental requirements and design guidelines to be considered when designing for group stability in confined environments. Such environments are to be found in the proposed space stations and space bases of the mid to late 1970's and 1980's.

In performing this effort, consideration was given to the organizational model and group characteristics of the NASA teams manning such facilities. It was recognized that crews of the space station and space base will differ, the distinguishing factors being: primary areas of interest; crew composition; and crew size. For the space station the crew will consist of a relatively small number of "professional" astronauts whose primary interest is in testing the feasibility of such facilities, with completion of some experimental programs being a secondary goal. A mixed team of astronauts and scientists will inhabit the space base, and their primary concern will be the accomplishment of scientific investigations rather than establishing the habitability of the life support environment.

While such differences will exist, a generalized NASA team model was developed that allowed for these "divergent" groups to work together. The model was essentially "pyramidal" in nature for both the professional astronaut and astronaut-scientist groups. In defining the group model consideration was given to the functional and demographic properties of such groups. It was believed that an understanding of specific group component characteristics would assist in determining design recommendations. Nine specific variable "group properties" were identified and explained.

Data from research programs utilizing isolated or confined environments were evaluated. These included the Sealab II exploration, Antarctic research projects, and laboratory studies conducted in controlled environments. Certain nominal discrepancies were noted which were minimal when compared with the similarities underlying the study results. The importance of experienced leadership, compatible personality types and organizational structure were underscored in all such "stressful" operational environment situations.

A review of the literature was conducted in order to ascertain the effects of the environment upon social interaction. This consisted of a review of proximetics theory and various other observational studies. The theory and studies indicate that task relevancy and status in the group (leader, no-leader) interact significantly with environmental parameters to determine seating patterns, separation distances, etc.

All aspects of the study were considered for developing the finalized listing of environmental requirements and design guidelines. The specific problems that might arise from various group sizes, crew mixes, and personality incompatibilities are not defined. Rather, general principles that should reduce some of the stressful conditions found in isolation and restricted environments have been presented.

# FOREWORD

NASA is currently investigating various aspects of establishing a space shelter that will have the capability of sustaining groups of individuals, ranging in size from six to one-hundred men, for periods of up to six months. Studies are investigating various aspects of such a shelter, such as food preparation, waste elimination, and other factors relating to "habitability" within this environment. Ultimately, it will become the responsibility of NASA and the designers for the contractors constructing the vehicle/shelter to integrate these studies in a meaningful manner so that an optimal environment is produced.

One aspect of space shelter research still requiring investigation is the degree to which social science findings relating to the man/environment interaction can be integrated with the design process. The present effort attempts to bridge this void by establishing habitability system environmental requirements and design guidelines which will serve to facilitate the group stability of the inhabitants. In order to accomplish this goal, the following tasks were undertaken:

- Identification of the psychosocial and interpersonal characteristics that may affect the individual crewman's behavior in a group under long-term confinement conditions appropriate to a space station mission.

- Definition of a model that is representative of the social process to be found in groups representative of the space station crew composition.

- Identification of important group properties that relate to the maintenance of group stability.

- Determination of the potential effects of a space station environment on the group properties in light of potential design parameters and alternatives available to NASA designers.

- Development of a set of environmental guidelines and requirements, properly weighted and in a format that would be usable by NASA designers.

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Mr. Armand Fiorenza participated in this study by conceptualizing and executing the creative design concepts and artwork. The authors are grateful for his efforts.

Dr. Robert Campbell proved to be an invaluable friend and associate who shared his information concerning man/environment interactions freely.

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# CHAPTER I: INTRODUCTION

In reviewing the literature pertaining to NASA habitability design concepts, it can be seen that the major concerns of these efforts were the requirements of the individual astronauts. As crew size varies the requirements for shelters are multiplied by some factor. In this manner the volume, water, oxygen, and other requirements are determined on an individual basis. This individualistic approach appears throughout the NASA literature, especially in studies such as STEM (1965), LESA (1964), MOLAB (1966), and Fraser (1968).

NASA's concern with the habitability characteristics of shelters can be seen in the second section of Volume II of their Standards and Criteria document (Preliminary Technical Data for Earth Orbiting Space Station, November 7, 1966). In this report, group considerations were noted in the introduction to the habitability section in the following manner:

> "For short duration missions, man will tolerate fairly primitive environmental situations as long as the physiological essentials are provided. However, long duration missions require the consideration of the human factors that are disregarded in short duration missions. System design utilizing habitability as the unifying concept will not only insure performance, but will maintain crew morale."

When discussing the intangibles of habitability during long duration space missions, Fraser (1968) recognizes that increasing the free internal volume and considering aspects of illumination, decor, color, and other "less common" aspects of a habitability system should improve astronaut performance. His analysis, however, does not recommend a specific design nor does it include the potential interactive forces that are found in groups. In many respects he, as well as the NASA document discussed above (NASA-TN-X-59700), remain principally concerned with habitability as it concerns the individual.

When discussing the preliminary design of a manned lunar laboratory, J. S. LaPatra, et al.,(1968) identified the importance of the group process to the success of such a mission. One of the long-term basic behavior science research programs recommended to be conducted included both individual and group evaluations of habitability and an analysis of the group process and development of the group in the "new" environment. These authors felt that "at this point in time, it appears that the major limiting factor in long-term extra-terrestrial activities is the problem of interpersonal relationships for the isolated individual."

Terrestrial investigations have been conducted in which the interactions between group members were studied while under "a stressful" environmental condition. The Sealab II (ONR Report ACR-124S Summary Report) interdisciplinary study was conducted to test the usefulness of ocean floor habitation, including the determination of stressful conditions and their effects on the group interactions of the aquanauts. This study obtained the following results:

- motivation and morale of the men were extremely high;

- group cohesiveness for all teams increased;

- men had personal dissatisfaction with the amount of work that each had performed.

In the summary of the report, it was noted that while man could inhabit the ocean floor in a Sealab II environment, "a re-evaluation of the entire habitat inside arrangement from the human engineering aspect is desirable."

In the LUNEX II simulation effort (1966), the two crew members who acted as subjects for an 18-day period were found to have maintained high morale during the experiment. Intersubject irritability was not present, however, irritability was noted in the latter portion of the simulation when an equipment malfunction occurred.

Most recently, the Tektite program and the drift of the Benjamin Franklin were evaluated in terms of the interactive nature of individual group members.

As can be seen from the studies and design efforts described herein, it is believed that a major needs exists to include consideration of interactive processes into the design of habitability systems. All habitability designs, and especially those being considered by NASA for use in future long duration space missions, should incorporate environmental features that are conducive to the maintenance of group stability. A concern for the maintenance of the group via environmental design and planning should have desirable interactive effects on each crew member's morale and functioning. This will facilitate performance, thereby increasing the probability of successful completion of mission objectives. The importance of enhancement of crew member interaction will be most noticeable on longer term missions, and on missions where crews are composed of individuals having diverse backgrounds and experience.

Previous studies relating to the development of a habitability system recognize that the shelter protects and sustains the crew members by supplying required EC/LS needs, including:

- shelter from hostile environments;

- habitat atmospheric and thermal regulation;

- operational and physical maintenance facilities.

In developing the hardware to meet these needs, NASA scientists and contractors are investigating the importance of free volume requirements, station compartmentalization, allocation of available free volume to compartments, decor, illumination, layout and arrangement of equipment to the functioning of individual crew members. It is recognized that each of these variables may produce noticeable effects on an individual's performance with resultant enhancement or deterioration of mission activities. However, as NASA extends the time periods that groups of astronauts or astronaut-scientists spend in space, and as the number of personnel on each flight increases, greater emphasis will have to be placed on the social and psychosocial factors affecting these groups. The initial space habitats will not be as complex

as their organizational counterparts on earth. With the extended time periods planned for future investigations, however, a greater range of group dynamic interactions will be possible. This is especially true as the organizational complexity of the missions increases as a function of larger crew sizes.

With longer space voyages and with the establishment of habitability shelters in space, larger numbers of space travelers will be living together in groups of varying sizes. For these individuals to perform at an optimal level, mission planners will have to consider all aspects of the environment that these "adventurers" will live and work in. An aspect of the environment that is extremely important to individual and group performance, one that is notable by its absence from NASA documentation, is the area of group dynamics and the potential effects of shelter design on the behavioral characteristics of the shelter inhabitants.

It is believed that the unique personality characteristics of the initial extended space station astronauts will enable optimal or near optimal performance, even in the face of potentially severe psychological stress. This assumption is founded on the high motivational states of individuals while accomplishing "new," "unknown," and "hazardous" feats. This belief is partially supported by the performance of the astronauts aboard Apollo 13. Confronted by a situation which did not allow for their immediate release to a "safer" environment, the crew interacted in a manner motivated by common striving or purpose of the group. In this "unique" environment their interactions might differ from those established in the terrestrial simulation environment.

The present study was conducted in order to provide NASA and NASA contract engineering groups with information concerning characteristics of groups and environmental parameters which might affect the stability of groups in extremely close contact for long periods of time. Inputs include a review of the literature concerning group dynamics. Data in this area have been derived in large measure from laboratory and unusual or stressful (field) environment studies. Each of these data acquisition sources provides important information which, to a great degree, is harmonious. For these reasons, data derived from both methods will be included in the discussions presented in the following chapters.

In the present study, the emphasis on psychosocial findings rests in the understanding that individual behavior and group behavior cannot be fully equated. This has been emphasized by Sherif and Sherif (1953) when they state:

> "Behavior in group situations has been shown time and again to be different from the sum total of behaviors of individuals A, B, C, etc., when they are alone. If characteristics prevalent among individuals of a group are products of group relationships and interactions, and not some essence of individual members, then the study of group differences must begin with an analysis of these group relationships and interactions, and not with individuals in isolation."

The objectives of this investigation were:

- Identification and definition of a set of environmental guidelines and requirements, presented in a manual useful to NASA habitat designers.

- A preliminary system of weighed rankings for the guidelines and requirements so that NASA designers can apply and generalize the results of this study to a number of habitats.

To accomplish these objectives, Concept Applications, Ltd., scientists have viewed the group, the individual crew members, and the shelter environment as interacting components of a habitability system. The systems approach toward developing group - environmental requirements implemented by Concept Applications, Ltd., has involved the identification of important group properties via a study of the variables influencing group dynamics, and includes an analysis of environmental features which have interacting effects on these properties. When reviewing the problem it becomes apparent that not all requirements or guidelines have an equal impact on group stability. As a consequence of the literature reviews and discussions with persons working in the area, the various properties and related environmental characteristics important for group stability have received a preliminary set of weighed rankings for each of the environmental requirements and design guidelines. In this manner, basic information was derived from which an evaluative system was then developed.

The worksteps accomplished in completing this study are presented below and correspond to the various chapters in the report. They include:

- The development of a model representative of the behavior and structure of future long term NASA space missions.

- An identification of important group properties related to the model of anticipated interactions between NASA personnel inhabiting the shelter.

- The identification of psychosocial and interpersonal characteristics of individuals who have undertaken long-term confinement conditions similar to a space station mission.

- A definition of the effects of the environment on the various group properties.

- The development of guidelines and requirements for designers.

- An assignment of preliminary weighed rankings for the guidelines and requirements.

## CHAPTER II: NASA GROUP MODEL

NASA teams can be described as specially selected, highly trained, and strongly motivated individuals acting in concert to carry out scientifically oriented missions under unusual environmental conditions. The fact that these teams are composed of volunteers who have survived and shared the rigors of exhaustive and extensive screening and training procedures leads to the *a priori* assumption that a strong sense of identification with the mission is found in crew personnel that can generalize to the group as a whole. If, as La Patra et al., (1968) point out "at this point in time, it appears that the major limiting factor in long term extra-terrestrial activities is the problem of interpersonal relationships for the isolated individual," the need for a habitat that will maintain or facilitate positive group interactions which strengthen identification and foster group characteristics such as efficiency, stability, cohesiveness, and morale, becomes obvious.

Although the pyramidal model of group behavior best characterizes initial NASA explorations using small groups and missions of relatively short duration, the feasibility of this model for situations in which potentially large numbers of personnel, with more varied backgrounds, are assigned to habitability structures for long duration missions, must be examined. An example of such a pyramidal model can be seen in Figure 1.

The levels of leadership in this model consist of discrete tasks and reporting sequences. Similar "chains of command" are seen in the family trees or reporting sequences in many industrial complexes. It is anticipated that in the earlier space missions, requiring fewer personnel and of shorter durations, the pyramid representing reporting and leadship levels will be of a restricted nature. Each crew member will have specific and assigned tasks. Generally, it is anticipated that one crew member will be in the top leadership position (commanding officer), and the other crew members will report directly to him.

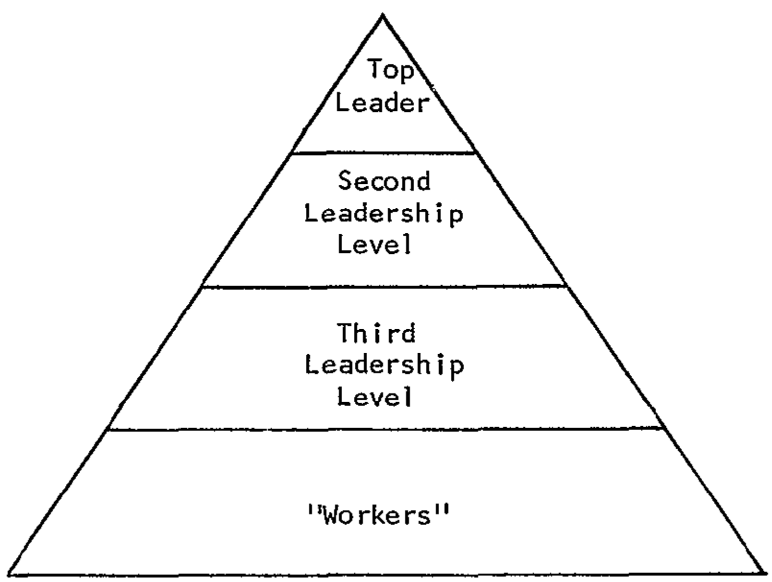


Figure 1. Pyramidal Model

With the advent of longer duration missions requiring larger crews the interactions between the various crew members will need a much broader base to allow for the necessary command structure. A generalized pyramidal model for longer duration missions is presented in Figure 2.

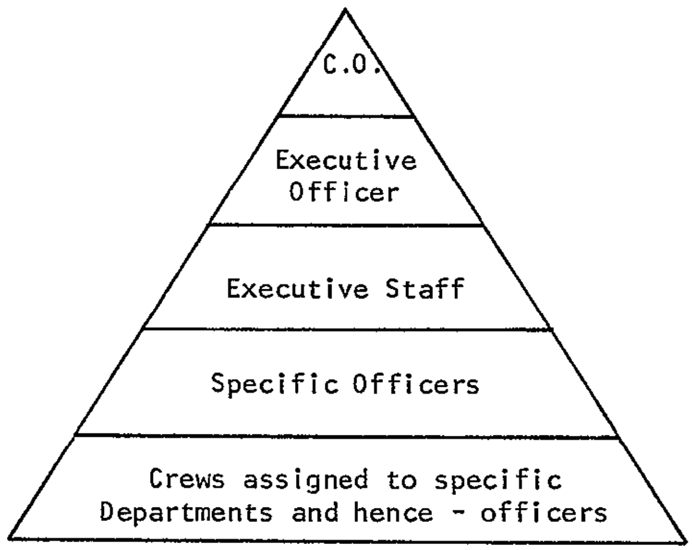


Figure 2. Generalized Pyramidal Model

As can be noted, there is great similarity between Figures 1 and 2. Leadership levels have been defined in terms of anticipated title designations. The potential complexity of the reporting structure can be seen in Figure 3 which represents some of the positions anticipated in a space base containing 60 or more persons.

Models presented in Figures 1 through 3 are typical of the pyramidal structure seen in industry and in previous NASA efforts. Other models must also be considered if all conditions in extended space flight are to be accounted for. An example of a slightly broader behavioral and interactive model that incorporates the salient features of NASA teams and duty missions is the work group model. Cartwright and Zanders (1968) describe the work group as one of non-spontaneous formation where the "basic condition for the deliberate creation of a group is the judgment by one or more people that a collection of individuals can accomplish some purpose (or do so at a level of efficiency) not otherwise possible." Work groups are formed "to perform some task more efficiently through the pooling and coordination of the behavior and resources of a collection of individuals .... An example is the formation of an expedition to explore the Antarctic, to climb Mount Everest, or to land on the moon." To a large extent the member's rank in the group and the importance of his specialized skills to the ultimate goal, successful completion of the mission, initially define and determine roles, expected behaviors, and interactions in this paradigm. To the degree each member has a unique and valuable contribution to make, status differences in the group may be negligible.

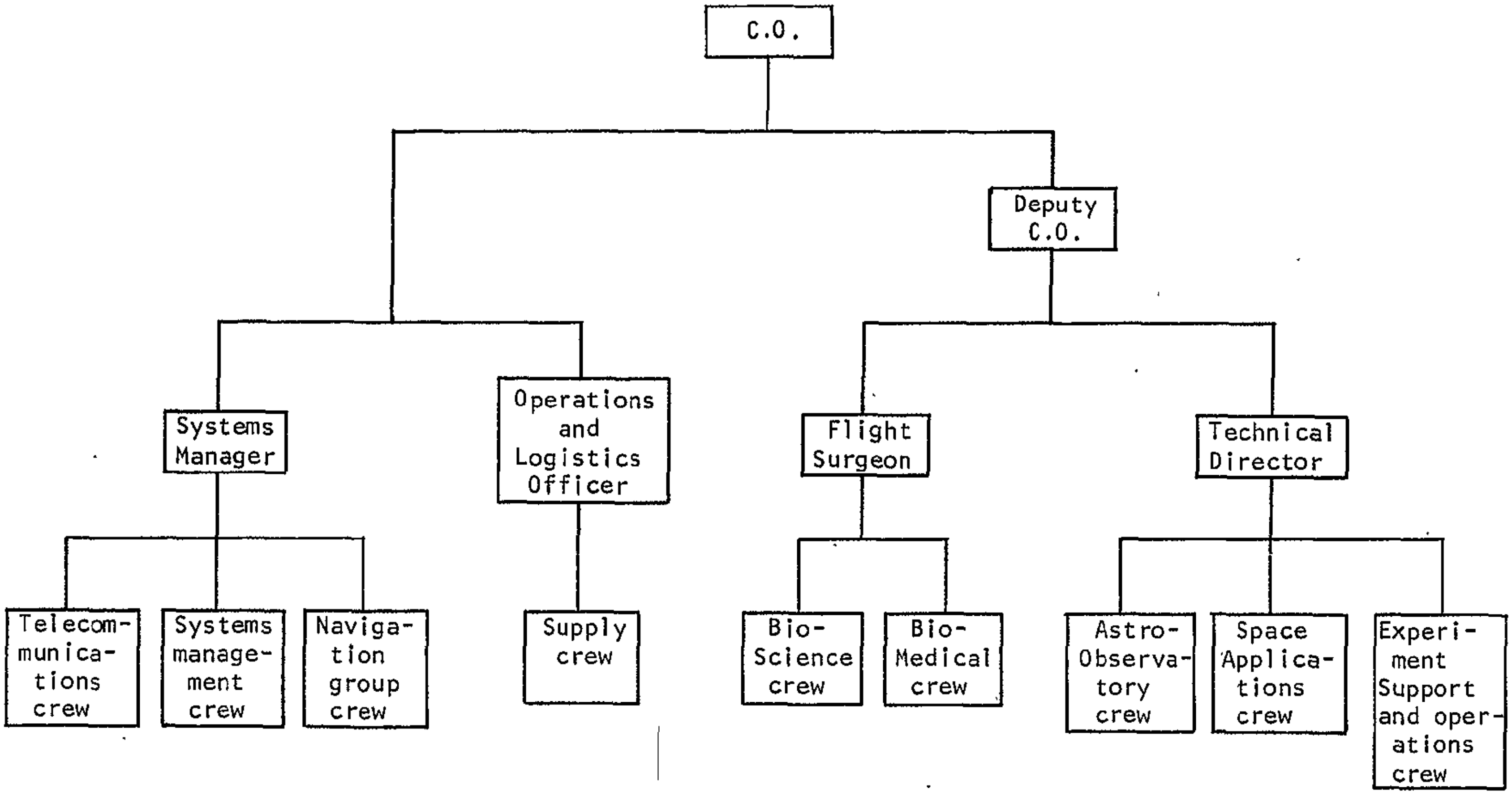


Figure 3. Generalized Space Base Organization

However, while the work group model may be the most suitable one for NASA team interactions in a task oriented milieu, missions of long duration with large crews confined to spatially limited, if not stimulus limited environments will provide numerous opportunities for non task or non mission oriented interfaces to occur. This second set of interactions, revolving about off-duty activities might best be depicted in terms of a social group of spontaneous formation. Here, the basic composition of the group is determined by processes of mutual consent with each member wanting to be in the group and is less directly related to rank or status per se.

Smith (1966) cites the development of an informal group structure during an Antarctic expedition. His description is as follows:

> "Two stages were identified, a task activity stage and an interpersonal stage. There were considerable differences in the temporal properties of each. The first took about one week to develop and the second approximately three and a half weeks. The order in which these stages occurred was opposite from that reported for therapy and training groups."

In an analysis of the development of the group structure it was suggested that the development identified was dependent upon the type of group, i.e., work group, social group, therapeutic group, training group, etc., as well as certain other elements, e.g., similarity and overlap of primary roles, influence of the developmental sequence, etc. It was thought that:

> "in groups where each person's primary role is different and independent, structure begins to develop first around those elements concerned with the primary purpose of the group; for example, in the traverse, the accomplishment of tasks associated with primary roles." (Smith, 1966.)

Thus, the first phase in the definition and identification of a group model projected as being representative of the interactions occurring among individuals assigned to habitability structures during long duration missions, consisted of an examination of group dynamics literature for potentially appropriate and relevant paradigms. Models were evaluated in terms of such factors as:

- conditions leading to group formation
- organizational structure
- primary function of groups
- types of groups

Table I summarizes the results of this assessment and also includes a number of specific societal examples of groups representing each model.

TABLE I. GROUP MODEL SUMMARY

| Model | Formation Condition | Structure | Primary Group Function | Types of Groups | Societal Examples |
|---|---|---|---|---|---|
| I | Deliberate (non-spontaneous) | Formal | Accomplish group goal or mission | work | explorations expeditions<br><br>manufacturing concerns |
| | | | | military | armed services<br><br>police |
| | | | | problem solving | research teams |
| | | | | social action | commissions<br><br>political parties<br><br>lobbies |
| | | | | mediating | courts<br><br>UN committees |
| | | | | legislative | senates<br><br>boards of directors |
| | | | | client | T groups<br><br>Topic House |
| II | Spontaneous | Informal | Meet psycho-social needs of members | | friendship cliques<br><br>informal groups within a formal organization<br><br>social clubs<br><br>gangs |

TABLE I. GROUP MODEL SUMMARY (Continued)

| Model | Formation Condition | Structure | Primary Group Function | Types of Groups | Societal Examples |
|---|---|---|---|---|---|
| III | External | Perceptual | None to perceived members | Cognitive and perceptual stereo-types | hippies<br>teenagers<br>"the poor"<br>eggheads<br>Negroes<br>Jews |

It can be seen that three broad categories of groups are reflected in this table with major differences existing among the groups with respect to:

- manner in which groups are formed
- nature and degree of organization
- specificity of membership roles
- purpose of group

The first model describes interactive situations wherein a highly organized and structured group is deliberately formed in order to achieve some specific goal or aim. Membership accrues through designative, elective, or selective processes with great emphasis placed on task oriented behaviors.

The second model characterizes the types of groups that develop under somewhat more social conditions. Organization tends toward the informal with the basic function of the group being the satisfaction of psychological and social needs of individual members rather than the achievement of some overt goal. Relationships and interactions result from a process of mutual consent between members. Roles and status within the groups are more likely to be determined by group processes than by formal rank, title, or position as in the first model.

The third paradigm accounts for groups that come about because certain individuals in a society are perceived or treated in a homogeneous manner by others. Membership is externally defined and certain kinds of behaviors are expected. Opportunities are made available or unavailable solely as a function of being seen as a member of the group. Interdependence and interactions among members develop essentially because the society at large assigns them common attributes and identity. This last model requires a crew size large enough for some members to possess similar characteristics or to engage in the same kinds of mission related activities.

One of the concepts basic to developing a NASA group model is that the three types of groups may be required to describe most adequately the interactions among NASA personnel likely to occur during long duration missions.

The dominant model initially appears to be that of a deliberately formed, task oriented group. However, other models will be needed to account for the full range of interactions as the size of the crew and/or complexity of the mission increases.

Sells (1966) has described a model for the social system for extended duration, multimanned space ships that provides some support for the social interaction concepts just proposed. Sell's model has five features which essentially coincide with the NASA group model being developed in the present study. These features are (1) a formal organization with prescribed responsibility, (2) crews composed of elite corps of highly selected, trained, and educated volunteer specialists, all extremely ego involved in the program and mission, (3) low organizational autonomy, (4) low formally prescribed status differences among crew members, and (5) high task demand and mutual dependence.

An analysis of the kinds of activities engaged in by crew members was seen as the second phase of the group interaction model identification. This analysis is necessary because these activities provide the opportunities for different kinds of interactions to occur. Table II presents a summary, based on five studies, of the percentages of total time expected to be spent in various activities.

TABLE II. PERCENTAGE OF TIME DEVOTED TO ACTIVITIES ON A SPACE STATION - SPACE BASE

| Activity | Percentage Range | Average Percentage | N of Studies |
|---|---|---|---|
| Work | 38 - 53 | 43.80 | 5 |
| Sleep | 32 - 37 | 34.40 | 4 |
| Personal | 7.5 - 17.8 | 11.70 | 4 |
| Nourishment | 0.7 - 12.5 | 7.05 | 4 |
| Housekeeping | 0.5 - 6.0 | 3.24 | 5 |

These data suggest that on an average day approximately 10.5 hours will be spent performing mission related behaviors, 8.3 hours in sleeping, and some 5.2 hours devoted to off-duty functions as eating, personal hygiene, rest, relaxation, housekeeping, equipment care, and waste elimination. The largest proportions of interactions (time-wise) will take place in work areas. It would, therefore, seem important to design these compartments in such a way as to take advantage of the interactive opportunities afforded. Off-duty hours can be employed to promote less determinate interactions and, in some cases, allow for freedom from interactions.

Sells (1966) has suggested that unnaturally confined quarters for work, living, recreation, and personal space may become a potential source of social stress. This would be true to the extent that the capsule environment fits the description of a total environment in which enforced association is continuous and without the respite of discontinuity found in more usual habitats. Unless some provision is made for tension-reducing discontinuities as solitude and privacy, these enforced contacts can generate and magnify interpersonal stress.

Assuming the desire for contact with other crew members outside work stations will vary as a function of each individual's personality and temporary emotional state, the areas in which non-mission related behaviors occur should be designed to satisfy both socialization and privacy needs of the astronauts.

For this particular study the particular model for group interactions that is most appropriate at any given time will be related to the activity that is occurring at that time.

To date, initial NASA explorations have been of relatively short duration and have been carried out with crew sizes of three or less. Under these conditions a quasi-military model of organization and responsibility for various phases of the mission has operated efficiently. Undoubtedly a good part of this success can also be attributed to the careful training and the attitudes inculcated into the astronauts prior to the actual flights. However, as missions become longer and the goals become more varied and complex, a situation in which larger numbers of personnel with more varied backgrounds are assigned to habitability structures, can be anticipated. For this reason, the continued feasibility of the quasi-military model must be studied.

In the evaluation of the three models previously described, it can be seen that Model I contains a sub-group, i.e., the work group that incorporates the salient features of NASA teams and duty missions. Table III compares the outstanding characteristics or features of work groups with the NASA mission team.

TABLE III. OUTSTANDING CHARACTERISTICS OF WORK GROUPS

| Parameter | NASA Team | Work Group |
|---|---|---|
| Purpose | Scientific exploration | Achieve a goal such as exploration |
| Organization | Structured | Structured |
| Membership | Selected from volunteers | Selected, elected, or designated |
| Rank-status | Activity dependent | Related to specialized skill |

It can be seen that a high degree of comparability is found with respect to reason for the group's existence, degree of organization, manner in which

members are obtained, and the way in which rank or status is determined. In the work group there is a high degree of organization with a member's role determined by the relationship of his specialized skill to the successful execution of the mission plan. This model is most applicable to behavior in the task oriented milieu.

However, as indicated by the activity analysis, numerous opportunities for non-task in mission interactions will be provided by the spatially limited environment encountered during long term missions with large crews. Model II, spontaneous social groups, best depicts the set of interactions that are likely to revolve about off-duty activities. In these situations, the basic composition of a group would be determined by a process of mutual consent rather than rank or mission requirements (military model). Festinger, Schacter and Back (1950) have found the composition of a social group in a housing project to be heavily determined by the architectural features of the project which was composed of a relatively homogeneous population. These data suggest that important factors influencing social group formation are physical proximity and acquaintance through occupational activities; both characteristics are present to a high degree on NASA missions. Specific variables that are likely to play a role in the evolution of the more informal social group within the astronauts, appear to be overall group size, environmental opportunities for interactions outside of work or duty station, and the number of crew members performing the same, or similar tasks.

In summary, two types of group paradigms are most likely needed to account for the kinds of interactions that will occur among NASA personnel confined to habitability structures for extended periods of time. In order to ensure the success of the mission and the safety of the crew members, a deliberately formed work group is essential. At the same time, interactions of a less formal, more spontaneous nature related to individual needs and conforming to a social model of group behavior, can be expected to develop.

These findings are confirmed in large measure in the following quotation from Gunderson and Nelson (1965):

> "As the needs and roles of group members vary over time, it seems likely that structural changes will occur within isolated groups in much the same way as they might in non-isolated groups. The major problem facing the isolated group is that it must restructure from the same population of individuals. For the present station groups, the larger parent organizations from which station members come and to whom they are ultimately responsible for their work undoubtedly supply a source of sanction operating against the deterioration of work structures. Also, the possibility of gross changes in task-oriented structures is somewhat reduced by the minimal overlap in task roles resulting from the diverse and highly technical occupational specialties found at these stations. Thus, the men tend to preserve work structures within specific occupational areas. Additionally, in terms of personal friendships,there is greater opportunity for variation in structure over time, particularly as group size increases .... There is some indication, from the present data, that off-duty friendships are not highly structured."

# CHAPTER III: GROUP PROPERTIES

Perhaps the greatest potential effect of the stresses associated with, or generated by, extended duration missions in spatially limited environments is upon the stability of the group engaged in the mission. As the ultimate success of the mission may well depend upon fairly harmonious and stable interactions between group members or sub groups within the crew this section will deal with the concept of "cohesiveness" as it is affected by various group properties and structures. A review of a number of possible definitions of this attribute suggests the most widely accepted one considers group cohesiveness to be "those forces which act to keep a person in the group and prevent him from leaving," (Cartwright and Zander, 1960).

Since the spatial limitations imposed by a habitability structure mitigate against the physical departure from the group by a crew member, other than by self destruction, the leave taking that might occur when cohesiveness decreases is of a psychological nature. The withdrawing into oneself or "cocooning" has been observed in a number of Antarctic studies and illustrates one possible detrimental effect of enforced proximity upon interpersonal relations and group interactions.

Nelson (1965) noted that "when faced with the stressful demands of an unknown environment, men attempt to provide some stable social structure. Changes in such structure tend to be a function of changing needs within the group or of the inability for an already existing structure to cope with current needs. Over time there is a tendency within isolated groups for formal authority structures to be less tolerated, for group structure to become less complex and, while intimacy increases, for general interpersonal concern to diminish. In addition, in previous studies of Antarctic stations, group attitudes of the men relevant to group compatibility, teamwork, and efficiency were observed to deteriorate from summer to winter."

In order for a concept to have practical usefulness and scientific acceptance, it must in some way be quantified or made amenable to measurement. The measurement of cohesiveness has been approached in a number of ways. These approaches are described and summarized in Table IV.

It can be seen that each item listed in Table IV is plausibly related to the definition of cohesiveness given previously and differs (with the exception of composite indexes) only with respect to the group attribute emphasized as best reflecting the effects of cohesiveness. While the utilization of composite indexes has suggested a general tendency for various indicators to be positively related, the relationship among indicators is not always consistent across all situations or groups. For example, Scott (1965), found no significant correlations between group attractiveness and interpersonal attraction among members of college fraternities and sororities. Both Gross and Marton (1952) and Eisman (1959) obtained no substantial correlations among three and five measures of cohesiveness respectively. Such findings reinforce the notion that while these approaches all assess logically related aspects of the group experience, significant results are likely to be yielded only when the measurement instrument is specifically tailored to particular situations and is meaningfully related to group features.

TABLE IV. GROUP COHESIVENESS MEASUREMENT METHODS

| Variable Measured | Techniques Used |
|---|---|
| 1. Personal Attraction (members name friends or rate other members) | Sociometric Indices<br>Rating Scales |
| 2. Attractiveness or Effectiveness (the "group" rather than its members is evaluated by members) | Rating Scales<br>Questionnaires |
| 3. Identification or Closeness (degree of personal involvement or identification with group) | Rating Scales<br>Questionnaires |
| 4. Membership Maintenance (desire to remain in the group) | Questionnaires<br>Projective Tests |
| 5. Diverse rather than single aspects (combination of above) | Composite Indexes |

It has been suggested by Cartwright (1968) that a person's attraction to a group (and hence the potential cohesiveness of the group) is determined by four interacting factors. These factors are:

- individual motives - need for affiliation
- reinforcements offered by the group
- individual expectancies of beneficial or detrimental consequences of membership, and
- comparison level of possible outcomes resulting from membership in one group as opposed to another.

Basically, a member is attracted to, or held by, a group because the group has properties that are more significantly related to the positive reinforcement of that member's needs than some other available group. This would hold for any one of the previously described groups. The four factors just mentioned appear to be influenced by a larger number of variables that form the basis of group attractiveness and cohesiveness. Table V summarizes these variables, research findings, and the significance of these data for extended flights or prolonged exposure to limited environments.

Although selection procedures, NASA goals and aims, and mission requirements ments and activities account for the largest portion of variance underlying these cohesiveness factors, it has been suggested that environmental features or architecture may be responsible for between 10 and 15 percent of this cohesive variance. In addition, the environment of the habitability structure

TABLE V. FACTORS INTERACTING WITH GROUP PROPERTIES WHICH AFFECT GROUP COHESIVENESS

| Variable | Hypotheses from Data | Significance |
|---|---|---|
| 1. Member attractiveness | If persons interacting like one another, interactions increase the liking; if persons dislike one another, increased interactions increase antipathies | Environment must allow for "privacy" or opportunity for non-interaction at times |
| 2. Member similarity | While attraction to a group can increase with increasing similarity (homogeneity) among members, dissimilarity sometimes enhances attractiveness | Provisions must be made for interactions between members of the crew with different assignments or backgrounds |
| 3. Group goals | Distinctive group goals or purposes attract people with similar motives. This fosters interpersonal bonds and group identification | Feedback should be fostered so that group goals and achievement can not act as a group reinforcement |
| 4. Group activities | Where group standards in various activities exceed a member's ability to meet them, dissatisfaction increases and group attractiveness decreases | A variety of recreational activities should be provided. They should fulfill the needs of the crew |
| 5. Leadership and decision making | Participatory leadership rather than supervisory leadership produces greater satisfaction and feelings of group efficiency | While seating arrangements can reinforce the sense of leadership (i.e., head of the table) a circular grouping fosters or can encourage greater participation |
| 6. Communication | Average level of satisfaction in a group is positively related to decentralized communication networks | Circular seating arrangements provide maximum opportunity to communicate with others |
| 7. Hierarchal structure | Satisfaction increases as a function of job status. Group members serving in high status positions or having a chance of moving from low to high status show greater attraction to other members of the group | Rectangular seating arrangements allow for a greater display of status levels |

TABLE V. (Continued)

| Variable | Hypotheses from Data | Significance |
|---|---|---|
| 8. Group size | Size affects attractiveness by its effect on other properties. If they become less satisfying, as size increases, satisfaction decreases | The environment should be flexible enough to allow for alterations in apparent group size |
| 9. Affective climate, atmosphere, milieu | While a "friendly" and accepting atmosphere tends to increase attractiveness, outlets for antagonisms are necessary | Recreational facilities should provide amusement and therapeutic/emotional outlets |

represents a potential behavioral or attitudinal modifying force. While the failure to provide crew members with some means of voluntary physical withdrawal (privacy) from interactions with others could produce a self-imposed isolation and psychological withdrawal, another equally detrimental effect upon the group is possible. An environment which forces interactions among members having negative feelings toward one another may well exacerbate hostile feelings resulting in conflictual or aggressive behavior. Both types of environment-stimulated behaviors would serve to undermine individual and group morale as well as reduce work efficiency.

A possible threat to the cohesiveness of any group as a whole, is the formation of "cliques" or sub groups within the larger organizational unit. To the extent the goals of these sub-groups conflict with the larger group goals (Hawthorne studies) or reduce the attractiveness of the original group, this fragmentation must be viewed as a potential problem area. A number of studies have been chosen to illustrate the parameters leading to sub-group formation. Burns (1955) described two types of sub-groups found in a factory setting; one formed by older men without hope of promotion and joined in order to gain fellowship and reassurance from others sharing their fate, the other by younger men and used to obtain advancement or rewards by circumventing formal procedures. Findings of other investigators (Altman and McGinnies, 1960; Haythorn, et al., 1956; McGinnies and Altman, 1959; Schutz, 1955, 1958) suggest groups evenly divided with respect to attitudinal or interpersonal qualities are likely to be susceptible to subgroup formation. On the other hand, those factors tending to produce cohesiveness should mitigate against sub-group formation. Consequently, groups under some common threat or stressor and/or of a homogeneous nature as to values, opinion, or attitudes can be expected to be more resistant to partition and fractionation. As might be anticipated, larger groups of 12 members were found by Hare (1952) to be more likely to form sub-groups than those with 6 members. As crew size in a mission increases it appears that greater opportunities for sub-group formations will be afforded. While this may be unavoidable, the environment should be structured so as to allow for maximum communication between members of various sub-groups to offset, to some extent, the increased communication between members within sub-groups.

## CHAPTER IV: POTENTIAL EFFECTS OF ISOLATED, RESTRICTED, OR CONFINED ENVIRONMENTS UPON INDIVIDUAL AND GROUP PERFORMANCE

In this chapter, data from three major sources will be discussed and evaluated. These sources are underwater exploration studies (SEALAB II), Antarctic research projects, and laboratory studies in which the effects of environmental features, task demands, and personality characteristics of group members upon both individual and group behaviors and performance are the salient experimental variables. In all cases, attempts will be made to assess the effects of stressful, dangerous, hostile, or isolated environments upon (1) the relationship of an individual to a primary or work group, (2) effectiveness of performance, and (3) individual differences in tolerating the particular environment.

Perhaps the most common attribute of these three situations is their stress-inducing potential. Generally, studies of human reactions to stress have been conducted in two ways, each way having certain inherent advantages or disadvantages and suffering from severe methodological problems. The first approach might best be described as field studies of naturally occurring stressful events. The Antarctic projects fall into this category. Chief research limitations derive from the usually uncontrolled nature of the research environment and the possibility that the investigators may be unable to make systematic measurements and observations over time, while the participants are experiencing stress.

The second approach involves exposing individuals to stress in a laboratory setting in which there is rigid control over the environment and the measurement techniques employed to determine, objectively, effects upon social behaviors and performance. The essential defects in this type of study are related to the ethical problems of inducing (1) a level of stress of a magnitude that approaches naturally-found stressful situations such as combat, disasters, flying, and the like; and (2) maintaining prolonged stress in individuals for extended periods of time in a situation where subjects should have the option of terminating the experience at will. At best, these studies may reflect the momentary or acute effects of stress rather than responses to chronically stressful situations. For long duration space missions, the ability to tolerate continued exposure to stress is probably a more important attribute of crew members than the ability to react appropriately to isolated or periodic episodes of stress.

However, SEALAB II can be conceived of as a setting that provided opportunities to combine the more naturalistic features of a field setting with a fairly well controlled environment and systematic measurement procedures. In fact, SEALAB II represented the first attempt that called for a relatively large group of men (N=10) to perform a variety of realistic and meaningful tasks in an extremely threatening and hostile environment demanding extensive life support systems for an extended period of time. That the dangers and rigors of underwater exploration are great is underscored by Astronaut M. Scott Carpenter's comment after spending 30 days in SEALAB II. He stated that "the ocean is a much more hostile environment than space."

In addition to physical dangers related to existing at a depth of over 200 feet beneath the sea, living and working conditions inside the 12-foot by

57-foot capsule were uncomfortable, crowded, and stressful. Scant privacy or space for personal effects, a six-degree tilt in two directions, a communication disrupting helium atmosphere prohibiting smoking, as well as high heat and humidity conditions fostering infections, constituted the major sources of discomfort to SEALAB's crews.

According to Radloff and Helmreich (1968), "the most striking conclusion drawn from both objective data and subjective impressions is that adjustment was very good throughout the period of life underwater despite extreme crowding and high levels of perceived danger and psychological stress.

"There were significant increases in the cohesiveness of the three teams studied, with little or no evidence of overt friction." "Differences among the three participating teams were small." They further report, "each team seeming to maintain an optimal level of adjustment throughout its sojourn underwater ... . Despite the high level of adjustment, there were individual differences in adjustment, performance and relations with other divers."

The hypothesis that "under conditions of common fate, individuals will develop interpersonal attraction," (Collins and Guetzkow, 1964) which would be reflected by an increase in group cohesiveness, was strongly supported by sociometric data. A significant increase in the choice of teammates over predive choices after 15 days of immersion was found. Observations by closed circuit television supported the order of the magnitude of increased cohesiveness among the three groups. Team I, which showed the greatest increase according to sociometric data, was observed in more interactions as a large group with little evidence of pairing; while the second team which had the smallest increase manifested less total group activity and more paired interactions. However, observed group differences were considered slight and in no cases were instances of overt bickering observed in any group.

The criteria used to measure adjustment were derived from three factors isolated by Gunderson and Nelson (1966) as determinants of the adjustment of individuals wintering over in Antarctica. These factors encompassed: (1) task orientation; (2) emotional stability; and (3) social compatibility. They were operationally defined as individual diving time and diver ratings by team leader (factor 1), diver's self report of fear in a mood adjective check list and number of missed meals (factor 2), and time spent interacting with peers, time spent in work areas, post choice of each man as a peer on a sociometric questionnaire, number of phone calls to the outside, and time spent preparing and cleaning up after meals (factor 3). As might be expected, these criteria were highly intercorrelated. By using a composite score based upon the factor loading of each variable on the first unrotated factor derived from a factor analysis of these measures, an overall measure of adjustment was obtained. This measure produced a picture of a high scoring (i.e., best adjusted aquanaut), that consisted of a worker highly regarded by his leader and highly chosen by his peers as a desirable teammate. This diver was a good performer (diving time) and indicated a low level of overt fear on the self rating. Little time was spent communicating with people outside of SEALAB II, few meals were missed, and a good deal of time was spent interacting with teammates rather than lounging in the laboratory area, by the high scoring aquanaut.

Analysis of data derived from pre-dive personality measures were disappointing in that an almost complete failure to predict adjustment was found. Neither the FIRO-B or the Allport-Vernon-Lindzey Study of Values, nor the Strong Vocational Interest Blank showed significant correlations to the adjustment criterion. This finding seems to be consistent with earlier studies (Holtzman and Bitterman, 1962; Peterson, Lane, and Kennedy, 1952) that failed to find significant relationships between personality factors and success in stressful situations. Thus, Radloff and Holmreich concluded " ... paper and pencil personality measures failed miserably in predicting adjustment to this stressful situation."

It is interesting to note that "territoriality" was not observed in SEALAB II. This is somewhat surprising in that numerous reports dealing with behavior in isolation and confinement emphasize the emergence of this trait. A number of reasons are offered to account for the lack of evidence of territorial behavior; the major ones being the extreme conditions of crowding so no spot could be consistently occupied and the crudeness of the measurement instrument. The aberrant forms of social behavior associated with high population density (Calhoun, 1963) were also not found to occur in the SEALAB II habitat. This might be a result of the recognition that, due to the "eyeballing and elbowing" nature of the habitat, cooperation and compatibility were imperative. The important consideration is that group harmony may not have been achieved without effort, but that the necessary effort was expended. Censorship and restraint in expressing irritations and hostilities occurred in the interests of overall good relations. These excellent group relations, even if somewhat "pseudo-cordial," served to enhance and maintain performance so that a high level of accomplishment of mission goals was achieved.

Finally, Radloff and Helmreich (1968) offer "criteria" for criteria that will provide an accurate picture of a social situation. They are: (1) the use of objective and quantifiable measures; (2) high method variance in criterion variables; (3) isomorphism of criterion variables with conceptual variables; and (4) the use of multiple data points.

The most comprehensive evaluation of the effects of wintering over at scientific stations in Antarctica has been performed by Gunderson. The major feature of this type of research is the length of time spent in prolonged isolation in a restricted environment. The complete physical isolation that the scientists and Navy personnel lived and worked in lasted for approximately 12 months. Thus, while the crowding and the more physically restricting characteristics of underwater and space habitats are generally absent from these studies, the long-term isolation dimension is perhaps best tapped by these investigations. As Gunderson and Nelson (1965) point out: "most efforts to measure group interaction and effectiveness have taken place in a laboratory or short-term field situations that do not take into account changes in group processes as a function of time. This shortening becomes critical when a major focus of interest is the ability of groups to maintain positive social attitudes and effective work behaviors over extended periods of time."

Their data derived from nine groups obtained from three Antarctic expeditions and ranged in size from 14 to 40 men, with an average group size of 28 men. Approximately 65% of the men in the groups were military personnel with the remainder being civilian technicians and scientists. The mean age

and number of years of job experience for the entire sample were 27 and 7 years respectively. Nine attitude scales were administered twice during the year to three of the groups in the first two expeditions. The testing occurred at mid-winter (after three to four months of isolation and restricted activity) and at the end of winter (limited outdoor activities resumed). In the third expedition, revised shortened scales were administered at an earlier winter period (one to two months and at the end of winter). The investigators then employed official reports, supervisors' records, assessments by psychiatric teams at the sites, and post expedition interviews with members and station leaders to identify the least effective group in each expedition. Principal identifying characteristics of such groups were persistent difficulties in keeping essential station equipment operating, repeated open conflicts between group members, and low motivation or morale reported at the end of the year by observers at the scene.

Gunderson and Nelson found that exposure to long-term isolation from the outside world produced a measurable deterioration in social relationships and work effectiveness during the latter part of the confinement period. Interestingly enough, individual adjustment and satisfaction did not consistently show a similar decline. This could mean that individual adjustment and satisfaction measures were not sensitive to change or that group processes are affected in this situation by variables not affecting individual members of the group. Scales measuring teamwork, efficiency, achievement, and egalitarianism were found to consistently discriminate between least effective and other groups, while the compatibility scale differentiated between these groups in one half of the comparisons.

These data replicate, to some extent, Seaton's (1962) findings that affective relationships in army teams, exposed to short-term hunger deprivation during temporary isolation on the Greenland icecap, deteriorated along with formal organization, social control, and mutual support. All in all, the results of studies of this nature suggest that while maintaining group organization, harmony, and efficiency during periods of long term isolation and confinement may be a difficult task, it is not an impossible one; and that the identification and measurement of those variables related to social processes and group interactions occurring in exceptional environments, is an obtainable goal.

The last area of research to be discussed in this chapter is that of controlled laboratory studies of the effects of isolation, stimulus reduction, or confinement upon small groups. The most prominent investigators of the social phenomena associated with exposure to restricted, isolated, monotonous environments have been Haythorn, Altman, and Meyers. They have primarily focused upon the effects of the interaction between certain personality characteristics (need achievement, need affiliation, need dominance, and dogmatism) and isolation upon emotional symptomatology, subjective stress, and interpersonal exchange in isolated pairs of men.

Assigning isolated and control dyads according to a 3 by 3 Greco-Latin square experimental design, nine combinations of personality characteristics were studied. The isolated pairs environment consisted of a 12-foot by 12-foot room equipped with double decker bunks, chemical toilet, storage cabinets, a table, two chairs, a lamp and a small amount of recreational material.

Instructions were delivered through loudspeakers with no mail, radio, watches, calendars, or outside communication allowed. The actual length of stay (10 days) was withheld from the subjects who were told the period could vary from very short to very long. Both isolation and control subjects followed a six-hour work and six-hour free time schedule, with the controls free to leave the room during ten-minute rest periods, but not during free time. All in all, the controls spent a minimum of 12 hours a day together, but had considerable access to outside stimulation after work in the form of unrestricted use of base recreational facilities and from being housed in Navy barracks.

The following conclusions were supported by the analysis of variance performed on the data:

1. Isolated pairs reported greater subjective stress but no more symptomatology than control pairs.

2. More emotional symptomatology for isolated heterogeneous dogmatic dyads than similarly composed control dyads.

3. Heterogeneous need achievement dyads reported greater stress independent of isolation conditions and greater emotional symptomatology in isolation than homogeneously low need achievement dyads. Dyads homogeneously high with respect to need achievement reported more stress than homogeneously low need achievement dyads in both the isolated and control situations. High achievement groups reported less symptomatology than heterogeneous achievement in isolation conditions only.

4. Heterogeneous need dominance dyads in both the isolated and control environment reported less subjective stress and emotional symptomatology than did homogeneous need dominance dyads. Pairs high in need dominances showed less recovery from stress than other isolated pairs.

5. Isolated dyads homogeneously high with regard to need dominance did not indicate greater subjective stress and symptomatology than low dominance dyads in isolation. The former group did, however, show slower return rates to normal levels of stress.

Basically, the results of the study support the hypotheses that social isolation is stress-inducing and that the stress is a function of interpersonal needs. Dominance and achievement appear to be more stressfully influenced by isolation conditions than do affiliation or dogmatism needs with the effect related to high levels of these motives rather than heterogeneity for dominance and homogeneity for achievement. Haythorn, Altman, and Meyers interpret their findings as indicating the "importance of group composition to functioning in isolated environments, and perhaps to other stressful situations."

Altman and Haythorn (196 ) use this data base to examine the influence of isolation upon the development of interpersonal relationships with the exchange

of personal information by group members as their measure of interpersonal exchange. Individuals in isolated dyads revealed more about intimate topics to partner than controls, but less than would be revealed to a best friend. In control dyads, the level of disclosure was about comparable to average persons. Isolates were found to reach a depth of disclosure similar to that achieved with close friends, although the magnitude was small. They describe the overall disclosure profile of isolated partners as " ... somewhat intermediate between that associated with average persons in a general reference group and close friends; whereas the disclosure profile of control partners reflected an even more casual relationship than that achieved with average persons in a reference group."

The relationship between self-disclosure and different group personality compositions were generally inconclusive, probably due to the small number of cases involved in the comparisons. Considering that subjects knew that they were being observed and that this might have suppressed interactions, the authors interpret their data as "probably conservative in illustrating the nature of interpersonal exchange differences that occurred."

Project RIM (Restricted Isolated Monotony) was undertaken at the Naval Medical Research Institute to examine the validity of earlier studies of isolated groups and employed longer periods of time, maturer subjects, larger groups and a more traditional military group structure than those of the previous investigators. The investigators used four independent variables in the study: (1) compatible vs. incompatible crews; (2) three-man vs. two-man groups; (3) crowded vs. less crowded rooms; and (4) senior vs. junior leadership. The design was a 2 by 2 by 2 by 2 factorial one with all conditions being set in the context of a scheduled 21-day period of isolation and confinement.

Compatibility was defined in terms of a rank listing of the ten most compatible and ten least compatible sets of four dyads and two triads obtained from a computer which was programmed to determine the hypothetical compatibility of all dyads and triads possible, from a pool containing six leader and eight non-leaders. Group size varied from two to three-man groups. The former to provide continuity with previous dyad studies, the latter to examine the triad so often used in military aviation and space vehicles. An isolation room structured to provide 70 cubic feet of space per man constituted the crowded condition while an isolation chamber allowing 200 cubic feet per man constituted the less crowded one. The leader variable was defined in terms of the grade with E-4 and E-6 considered senior, while the E-2 and E-3 members were considered junior. In addition to the 21 days in isolation, six to seven days were taken up with "pre-confinement" procedures (testing, orientation, baseline physiological and psychological measurement). A four to five-day "post-confinement period was utilized to detect personality, mood, and physiological differences resulting from the 21-day period of confinement. With the exception of a daily task and questionnaire session, all other activities (sleeping, eating, recreation, etc.,) were unscheduled.

Data collection during confinement included extensive observational material (eight one-hour periods of behavior logs per day), 20-second automated video recordings taken 16 times per day, manual video-samples, audio recordings during free interaction periods, unusual events log, task and questionnaire sessions, and EEG tracings. The questionnaire battery measured

subjective stress, mood, emotional and medical symptomatology, interpersonal perceptions and exchanges, reactions to each other, experiences during the mission, reactions to the environment and experimental conditions and sleep and dream experiences. Tasks consisted of vigilance, rapid verbal reasoning, cooperative cryptography problems, perceptual dot estimation, and a discussion situation involving intellectual, emotional, and attitudinal components used to measure group effectiveness in interaction.

Only one of 35 groups terminated the study early, sharply in contrast with early studies in which up to 54% of the subjects aborted, with shorter (7-10-day) mission durations. This finding was attributed to the more mature experienced subjects, traditional military structure with a clearly defined leader, better diet, and a monetary incentive for participation.

After an intensive analysis of the data the authors felt the data provided clear support for the seven conclusions that follow:

1. The use of mature subjects in a structured setting produced less stress.

2. Despite the above, subjective stress and state anxiety were significantly elevated and feelings of happiness were depressed during confinement.

3. Compatible groups manifested less hostility toward partners, but were more annoyed with physical features of the rooms.

4. In difficult situations, i.e., incompatible, confined, three-man groups, senior leadership was generally more effective than junior leadership.

5. A significant reduction in the frequency of alpha rhythms of the ten subjects who underwent EEG recordings occurred. This was consistent with earlier sensory and perceptual deprivation studies, and with Russian simulation studies of space cabins.

6. Task performance in a task involving rapid reasoning was impaired by the group incompatibility condition while performance in a vigilance task was maintained at a high level of effectiveness.

7. Crowding did not appear to be a powerful variable in and of itself, but did interact in a significant manner with group size and seniority of leadership.

Perhaps the most important findings of these studies for extended duration missions is that the traditional military model with experienced leadership operated relatively efficiently in the worst experimental conditions possible in this study. The finding that hostility was internalized "or directed at physical features of the room rather than partners" is an interesting one. It may turn out that the inconveniences inherent in extraterrestrial habitats can serve to reduce aggression within a compatible group by focusing anger upon an obvious source of external irritation.

## CHAPTER V: MAN-ENVIRONMENTAL INTERACTION

The research reported, to this point, has largely dealt with the nature of groups (organizational properties and characteristics) and the effects of relatively long-term confinement or isolation upon relatively small groups of individuals. These studies have been conducted in both field and laboratory settings by American scientists. The social and interpersonal relationships found in "isolated" groups has also been studied by Russian scientists. In the *New York Times* of October 6, 1970, Walter Sullivan reported of the analysis of group dynamics conducted by two Soviet members of the international crew aboard the Heyerdahl Atlantic raft crossing. They were Y. A. Senkevich and M. A. Novikov. The article states that:

> "The two Soviet scientists reported that, in their view, an international crew, in a situation of confinement, prolonged isolation and peril was beneficial. Confrontation with common problems and dangers soon broke down the barriers rooted in nationality, they said, as when the raft began sinking and had to be lashed together.
>
> "The patterns of alliance and hostility fluctuated, they reported, although Mr. Heyerdahl always retained his position of leadership and good relations with all. A commanding personality, in such a situation, is 'extremely important' they said, and Mr. Heyerdahl well fulfilled that role."

After presenting sociograms representing the changing "patterns of friendship and hostility" that transpired, they concluded:

> "that only on space missions longer than two months would the effects of group dynamics be serious."

While the time interval of two months might be realistic for the "cruise" described above, some of the literature indicates that this time period might be much shorter (Seitz et al., 1970). Variables that will effect this temporal process include a limited number of factors. Sells and Gunderson (1970) list eight such categories. These include:

- Objectives and goals
- Philosophy and value systems
- Personnel composition
- Organization
- Technology
- Physical environment
- Cultural-social environment
- Temporal characteristics

Many of these categories have been discussed earlier since they relate to organizational characteristics, group properties or personality variables. An area yet unexplored relates to man's interaction with his physical environment. While considered by some to be "secondary" in terms of its effects, the results of the physical environment on individual and group behavior have come under increasingly greater scrutiny.

Fitch (1970) has noted that:

> "the boundaries of all architectural volumes are delimited by surfaces (floors, walls, ceilings) which constitute the second interface between man and the macrocosmic world of nature. These surfaces play a decisive role in the way we respond to and behave in the spaces they enclose ...."

He further identifies one of the major objectives of the architect as being the "successful adjustment between the organism and its environment." In order to accomplish this end, the architect must consider three basic elements. These are ergonomics, anthropometrics, and proxemics.

The present section is concerned with the area of proxemics. Fitch (1970) defines proxemics as:

> "the study of behavioral consequences of spatial relationships for interpersonal relationships of all scales and types."

This area has a limited history of investigation as it has only been studied in any detail by social scientists for a little longer than the past decade. As such, it has a small but growing literature pertaining to man's utilization of space, and the effect that spatial arrangements have on individuals and groups. The concept of "space" as it will be used here does not only imply "floor footage" or "cubic volume" surrounding the individual. It also includes artifacts within the environment that help structure interpersonal and personal utilization of the area.

One of the first social scientists to involve himself and the American public in the use of space and its effects upon individuals and groups was Edward T. Hall. His publication, *The Silent Language*, (1959), describes how various cultures use manners and behavioral patterns in the communication process. Allusions to the use of space in various cultures and the effect and manner with which people use space while communicating, are found.

A second book, *The Hidden Dimension,* (Hall, 1966), deals with the concept of space and its interactive effects on man at greater length and in much more detail. It is here one finds the delineation of four major distance zones; the intimate, the personal, the social-consultive, and the public. These are used to describe activities that occur from less than one foot to separation distances of over thirty feet. In this publication, Hall notes that various cultures have different conceptions of space. What is conducive to social interaction in one culture will hinder it in another. In a similar manner, what is conceived of as a "normal" distance for individuals to converse in in one culture, will be considered excessively close by a second culture, and excessively distant by still a third culture. To a large measure, this

results from the interplay of various sensory receptors and cultural anticipation. In this manner the auditory, visual, thermal, kinesthesic and olfactory receptors interact with cultural anticipation to prescribe specific separation distances between individuals in specific situations. A modification of Hall's chart indicating the interactive effects of sensory receptors and proxemic perception is seen in Table VI. While Hall presents each distance classification in two phases (close phase and far phase) the present depiction does not differentiate the distances this closely.

TABLE VI. INTERACTIVE EFFECTS OF SENSORY RECEPTORS AND PROXEMIC PERCEPTION

| Receptor | Separation Distance | | | |
|---|---|---|---|---|
| | Intimate | Personal | Social-Consultive | Public |
| Kinesthesia | Allows for the deliberate or accidental touching of others | Allows for contact within these ranges: two people barely have elbow room, out of interference distance | Allows for contact if both parties participate | No physical contact |
| Thermal | Limited awareness | None | None | None |
| Olfactory | At very close distances, some body odor may be considered desirable. In American culture, if this is not a masking aroma, it is usually considered undesirable | If not a "masking" odor, this is usually considered objectionable | Usually none | Usually none |
| Visual | Vision is distorted. Use scanning and head movement to see the person | Some enlargement of features. Use of scanning and head movement to see the person | Person appears "normal" | Person begins to appear "small" |
| Auditory | Whisper or soft voice | Soft voice to conventional or modified voice | Casual or consultive style to a loud voice | Loud voice |

Researchers in psychology have also shown increasing interest in the use of space. This has occurred in the social-psychological/communication, and the clinical psychological fields. An example is the study of communication nets and problem solving. Four typical nets can be seen in Figure 4. The efficiency of such communication networks progress in order from A (the circle) through D (the wheel), with the wheel being the most efficient. It is believed that if satisfaction measures were derived from such studies the flexibility of the wheel arrangement would lead to the choice of this as being most desirable from the subject's self satisfaction viewpoint. While the communication studies do not attempt to analyze the spatial factor in such groups, the circular, or wheel arrangement (modified) was shown to be an important configuration in the speech patterns of discussion groups also.

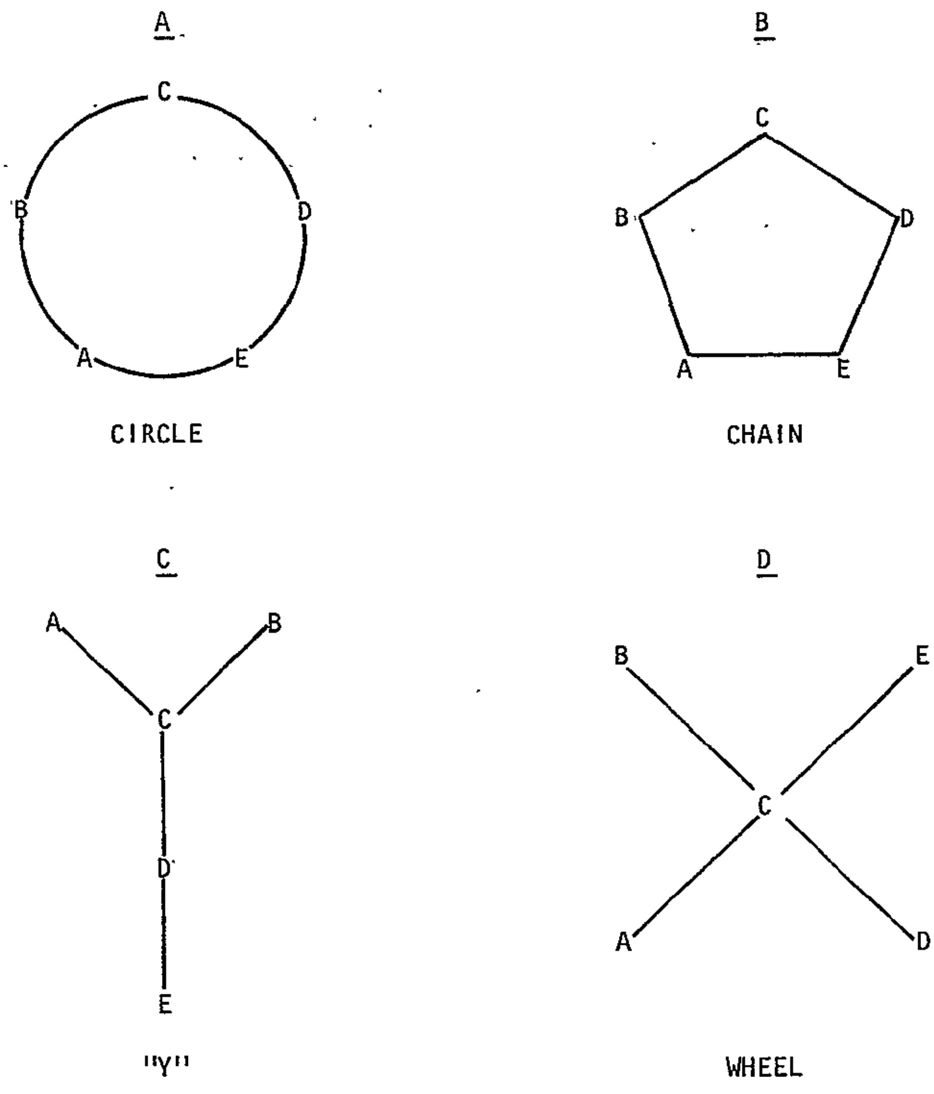


Figure 4. Typical Communication Networks

Steinzor (1950) noted that seating arrangements in a discussion group could be a determinant of the patterns of conversation between group members. He, much as Hall (1959, 1966) believed that:

> "Interaction among people was not only affected by the content of what was said, but by such non-verbal factors as gestures, posture, and more generally, the total physical impression the individuals made on each other."

To study the validity of this belief, Steinzor investigated verbal interactions of two groups of individuals. The "subjects" had arranged their seats in a circular arrangement similar to the one seen in Figure 5.

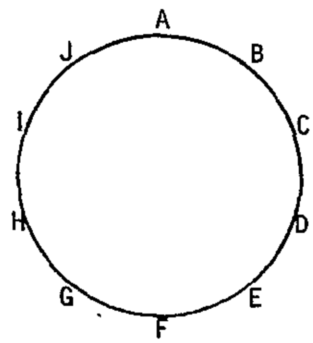


Figure 5. Typical Circular Seating Arrangement for a Group

The results of the investigation tended to confirm the belief that "in a small group seated in a circle, the greater the seating distance between two people, the greater the chance they will follow one another verbally." When analyzing Figure 5, this means that if the person seated in position A has spoken, there is a better than chance probability that persons in seats C, F, or G would respond than any of the other group members. To a large extent this is due to the visual field available to the group members. These group members (E, F, and G in relationship to A) have the greatest visual interplay with minimal visual distortion or physical movement required to obtain the visual impression of the speaker, A.

Charles Winick and Herbert Holt (1961) have noticed that the seating position taken in a therapeutic group session can yield insights into the effects of the analytic session(s). This is due to the nonverbal communication expressed in seating arrangements during the therapeutic process. The variability of such seating choices and arrangements express the subject's needs for privacy, territorial behavior, feelings of cohesiveness and unity with the group, and many other behaviors noted in researches in proxemics and of persons in confined and isolated environments.

Robert Sommer (1959) also has performed observations and experiments in seating patterns of various groups. In an observational analysis of seating arrangements around a table, and interactions during a noon meal in a staff

dining room in a mental institution, it was found that "neighbors" tend to interact more than more "distant" persons. The interactions occurred around a table depicted in Figure 6.

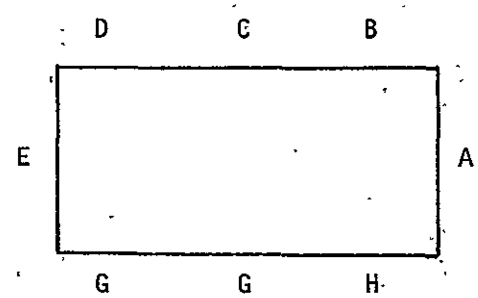


Figure 6. Table and Seating Arrangements Available

The findings of this study indicated that interactions between persons seated next to each other, in a corner-to-corner relationship (E-D, E-F, or A-B, A-H) were greater than could be anticipated by chance. This did not occur for other seating arrangements such as side-by-side or across the table from one another.

In an extension of the above mentioned observations, Sommer then conducted several experiments, using both normal and psychotic subjects in two and three-person groups. Sommer's initial observations were confirmed. More of the "normal" subjects selected corner seating arrangements (A-B, A-H, E-D, E-F, or E-0-F, A-B-H) than any other seating pattern. In this study, the psychotic subjects selected the most distant seating arrangements, which was interpreted as indicating a disturbance in social perception.

Sommer reports two further experiments in proxemics in this paper (1961). In one, the seating patterns of groups containing three, four, five and six persons were examined, when the arrangements occurred around the same table as shown in Figure 6. These groups contained a leader. The most commonly used seating arrangements, depending on group size, can be seen in Figure 7.

This analysis indicated that if the leader was seated in an end of the table position (seats A or E) the members of the group chose seats that were closest to the leader. This pattern generally occurred when the leader chose a corner position also (seats D, F, B, or H). The members of the group would organize themselves so as to be in close proximity while being able to view the leader. Due to the limited number of chairs, the larger size groups required a side-by-side (to the leader) seating arrangement. Typically, however, this was avoided when possible.

In a replication of the above experiments, using leaderless groups, it was noted that:

> "The dominant seating pattern in groups of all sizes was around one end of the table. When one end chair was occupied, it was extremely unlikely that anyone would sit at the other end chair."

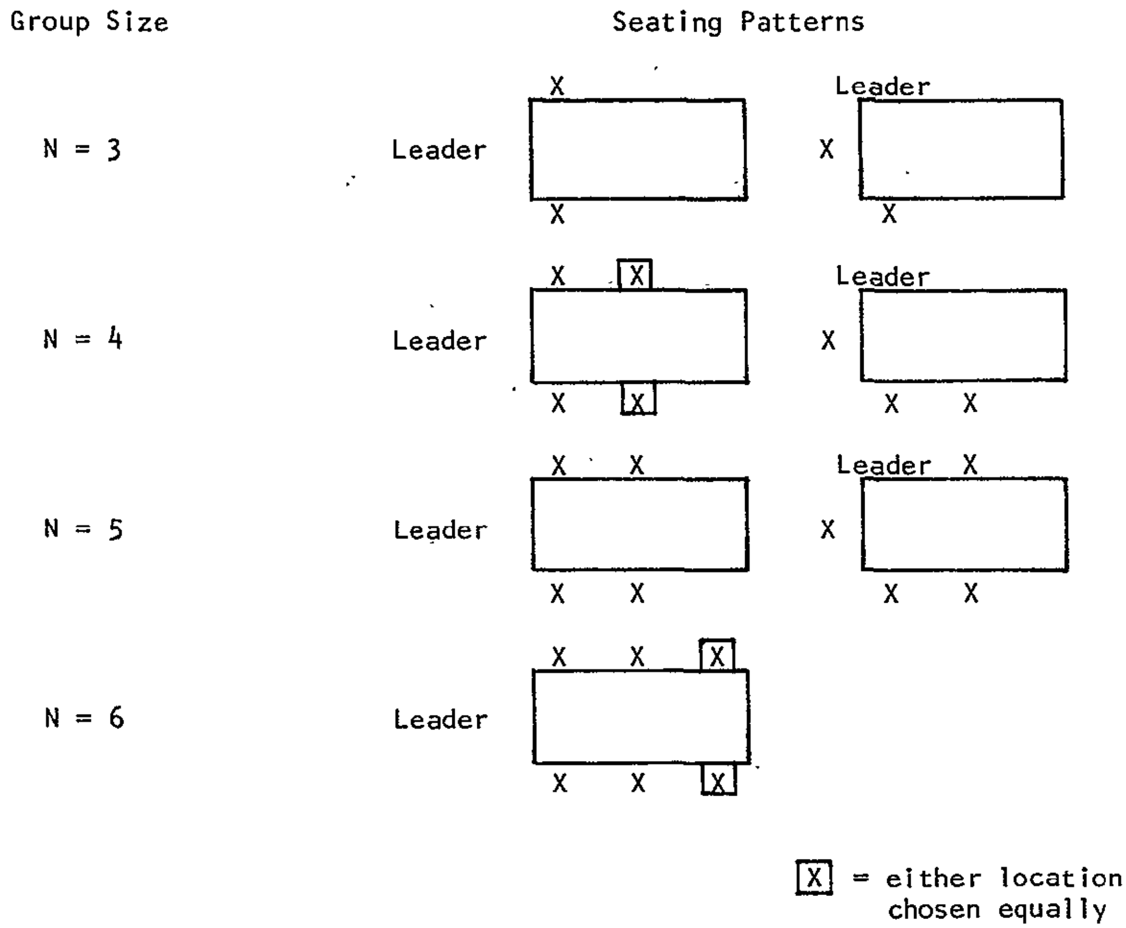


Figure 7. Most Common Seating Patterns of the Various Size Groups

Thus, regardless of the leadership nature of the group, seating patterns remained relatively constant.

Since the above-mentioned research analyzed seating patterns and not interpersonal seating distances, Sommer (1961) also investigated this variable. By having subjects enter a room in which two couches were placed at specific separation distances, it was possible to determine if they would choose seating patterns on the same couch or on different couches, as a function of the separation distance between these furnishings. In this study, once the separation between the couches reached three and a half feet, the subjects overwhelmingly chose to be seated on the same couch. When the separation distance was less than three and a half feet, the subjects selected individual couch seating patterns. While they did not necessarily sit directly opposite one another on the individual couches, Sommer concluded that:

> "Our subjects began sitting side by side when there were five and a half feet between persons. Under the particular conditions we used, this can be assumed to be the upper limit for comfortable conversation."

This finding is supported in the composite data shown in Table VII.

TABLE VII. SEATING PATTERNS BETWEEN PAIRS OF SUBJECTS AS A FUNCTION OF THE DISTANCE BETWEEN SUBJECTS

| Distance Between Couches | Number of Pairs of Subjects Sitting: | |
|---|---|---|
| | Opposite | Side by Side |
| 1 to 3 feet | 31 | 12 |
| 3-1/2 to 6 feet | 4 | 32 |

In generalizing his data, Sommer (1961) believes:

> " ... there are many similarities between even superficially different geographic settings which make some generalization possible from one setting to another. For example, all square and rectangular tables have similar geographical relationships between people seated side by side or those seated corner to corner. It is only the relationship between people sitting across from one another that is affected by the dimensions of the table. There are also similarities between square and round tables. If large round tables are used, the relationship between adjacent persons tends to resemble that between people seated side by side at a square table. If small round tables are used, the relations between people seated across from one another resemble the relations between people seated across from one another at square tables."

Sommer (1965) expanded his studies of proxemics to include special behaviors and patterns on the college campus. In a student union observational study, seating patterns were analyzed around two sizes of tables. In one case, the tables were 36 inches by 54 inches, while in the second case the tables were 36 inches on each side. These arrangements can be seen in Figure 8.

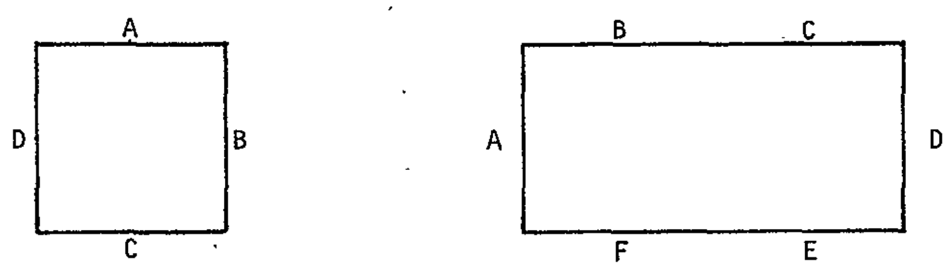


Figure 8. Seating Arrangements

The observations concerned themselves with seating patterns of individuals and contingent behaviors. The behaviors possible were either interaction, defined as conversing or studying together, or co-acting, defined as occupying the same table but exhibiting independent behaviors. The results of these observations can be seen in Table VIII.

TABLE VIII. SEATING PATTERNS AS A FUNCTION OF TABLE SIZE AND BEHAVIOR

| Seating Arrangement | 36" x 36" | | 36" x 54" | |
|---|---|---|---|---|
| | Interacting | Co-acting | Interacting | Co-Acting |
| Corner to Corner | 66% | 10% | 54% | 0% |
| Across from each other | 34% | 90% | 36% | 32% |
| Side by Side | | | 6% | 0% |
| Distant | | | 4% | 68% |

The results are similar to those of earlier studies (1961). Interacting individuals prefer corner to corner seating most followed by across table seating patterns. This was true regardless of the size of the table. For co-acting individuals, there is the desire for separation. At square tables this is accomplished by sitting opposite one another, while at rectangular tables, this could be accomplished by seating arrangements such as D-F, D-B, E-B, E-A, etc. These arrangements allow for both geographical as well as visual separation. Observations in a library setting, which can be conceptualized as requiring co-acting behavior, further confirmed the previous analyses that people will select specific seating patterns contingent on their desire for interactive vs. co-acting behavior.

The use of questionnaires ascertained seating preferences for both rectangular and circular tables. There were four conditions the subjects had to contend with. These were conversing, cooperating, co-acting and competing behaviors between individuals sharing the tables. There were six chairs at each table, regardless of table shape. The table configurations can be seen in Figure 9, while the results of this survey can be seen in Table IX.

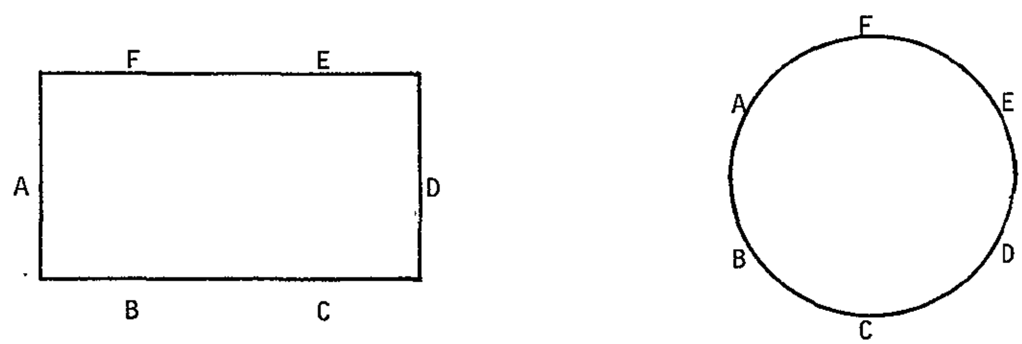


Figure 9. Potential Seating Choices from which the Subjects could Choose

An analysis of Sommer's research (1961, 1965) indicate the importance of visual contact in seating patterns. This is confirmed, not only from a review of the statistics of his various studies, but is also verified by subjective responses of respondents in the questionnaire studies. Patterson (1968)

TABLE IX. PER CENT OF SUBJECTS CHOOSING SPECIFIC ARRANGEMENTS

| Seating Arrangement | Conversing | | Cooperating | | Co-acting | | Competing | |
|---|---|---|---|---|---|---|---|---|
| | ▭ | ○ | ▭ | ○ | ▭ | ○ | ▭ | ○ |
| A - B | 42 | 63 | 19 | 83 | 3 | 13 | 7 | 12 |
| B - F | 46 | | 25 | | 3 | | 41 | |
| B - E | 1 | | 5 | | 43 | | 20 | |
| B - D | 0 | 17 | 0 | 7 | 3 | 36 | 5 | 25 |
| B - C | 11 | | 51 | | 7 | | 8 | |
| A - D | 0 | 20 | 0 | 10 | 13 | 51 | 18 | 63 |

summarizes Hall's (1959, 1966) and Sommer's (1961, 1965) work and notes that:

> "Intimate distance, 0-18 inches, combines visual, olfactory, and thermal sensations to signal unmistakable involvement with another body. At this distance there is often visual distortion of the other person and a sensing of that person's breath. Personal distance, 18 inches - 4 feet, is that distance which comfortably separates individuals. It can be likened to a protective sphere which is maintained by the individual. Social distance, 4 - 12 feet, substantially reduces involvement, while public distance, greater than 12 feet, is generally outside the circle of meaningful involvement with others."

Findings by Willis (1966) also verify that most conversations occur within Hall's definition of personal distance or space.

A current trend in office planning has been developed by the Bürolandschaft School of Design. One of its supposed attributes is its ability to facilitate communication. Shiff (1968) believes that, in the traditional gridlike office layout, people who need to communicate with each other find walls and doors in the way. The office landscape concept does away with such barriers by laying out the office along logical lines of work flow and communication. An engineered systems concept, it uses screens and dividers, thick carpeting and baffled ceilings, to provide visual privacy and to reduce noise; background music produces a masking effect. Executives and staff are put together in functional groups. Conference rooms located outside the area can provide privacy if needed. The general result is privacy without isolation, and direct visual control of the office unit.

In an interesting and imaginative use of the semantic differential, Brookes (1970) analyzed subjective reactions to the office environment. The study reviewed personnel from the same organization under two conditions.

Initially, the study was conducted while the staff occupied traditional offices, and later after the staff had moved and adjustment to a new landscaped office had been achieved. The results indicated:

> "... group cohesiveness may be slightly improved and this should be examined in the months to come in the light of change in rate of staff turnover. There should be a slight decrease in staff turnover, if anything.
>
> " Dramatic efforts should be made to decrease the hustle and bustle and to provide the staff with more space and facilities. There is a need for more privacy, both real and visual .... The noise of others' conversations is a depressing irritant as is having one's own voice overheard. The physical environment is fairly satisfactory. Most of all, the staff rate the aesthetics and decor highly."

A problem identified in the Brookes (1970) study, that is associated with the new office landscape, and is consistent with findings of previously mentioned authors, related to the importance of the visual field in social interaction. Brookes reports that "by and large, the only major changes (between the old and new offices) appear to be that the landscaped design is less efficient but a more sociable place and better looking." The sociability aspect was apparently enhanced by the removal of walls, which acted as barriers.

The need to recognize areas where such design concepts could and should be employed by NASA personnel can be found in the following results of this study:

- "The visual business of the space affects its occupants who wish for more privacy."
- "The landscaped office is perceived as more open and less private than the old, despite attempts made to decrease vistas." vistas."

This lack of privacy is not only found in the perception of the visual field but also exists in the auditory realm.

In summary, the research reported in this chapter confirms the belief that the environment helps to structure personal-social interactions. Apparently, the visual and auditory perceptions have primary functions in this process. However, the other sensory modalities are also deterministic in this process but usually to a lesser degree. Additionally, task performance and the nature of and physical patterning of artifacts present in the environment are also critically important interacting variables.

# CHAPTER VI: GUIDELINES AND RECOMMENDATIONS

The major intent of this report was to review the literature that would indicate important variables affecting group stability. In particular, its objectives were to derive guidelines and recommendations that could be used by NASA designers when considering habitats that will confine crew members for long periods of time in isolation and/or confinement. This section presents the guidelines and recommendations derived during the course of this study. They represent generalizations that concern the environment of "confining," isolated habitability enclosures, such as those anticipated in the next generation of space endeavors. It is believed that these guidelines and recommendations will be valid for terrestrial habitats where the users will encounter isolation and confinement because of an unusually hostile environmental condition.

One of the initial premises was that the guidelines and, in particular, the recommendations derived from this study would be weighted in accordance with the impact that they might have on the crew's stability. A review of the literature does not warrant such a weighting factor at this time. An analysis of the literature does not allow the investigators to assign a percentage to the amount of variance accounted for by any one specific guideline or recommendation. For this reason, all guidelines and recommendations have an equivalent weight in this report. It is believed that additional research into this area would be of great assistance to designers, but this is a problem for future study and investigation. Where items of specific importance have been isolated, they have been noted. In this regard, it is recognized that there are many interactive aspects of the guidelines and recommendations presented herein. These relationships will be noted and integrated to the greatest extent possible.

The following is the listing of the guidelines derived. They are presented in capital letters, with any explanatory information in normal type face.

## SPACE HABITATS SHOULD IMPLEMENT INDIVIDUAL AND GROUP ACTIVITIES

Previous NASA studies have placed a major emphasis on the individual. It is realistic to investigate the mobility patterns of individuals under a weightless condition, and then to generalize to a larger population. In the same light, it is meaningful to calculate the amount of food ingested by the "average" astronaut, and assume that "X" number of astronauts living for an extended period of time should consume some multiplicative function of the initial amount of food. This type of experimentation and calculation is valid for many aspects of future long duration space flights. As noted earlier, however, such flights will necessitate larger crew sizes, living together for longer periods of time. For this reason, it is believed that NASA should investigate the needs of both individuals and groups under comparable conditions. The interactive forces present in groups of individuals, living and working together for long periods of time might differ from such groups under shorter periods or under differing "hostile" environments. The various requirements for group stability should be studied further, and any additional information pertinent to habitat design and group stability should be incorporated into the future habitat structures.

## SPACE HABITATS SHOULD REPLICATE AS CLOSELY AS POSSIBLE THE ENVIRONMENTS FOUND IN THE ASTRONAUTS "NORMAL" ENVIRONMENTS

In the earlier space flights, in particular, crew members will be living in a particularly hostile, stressful environment. Any failure of the EC/LS or other critical systems could result in the death of the crew members. In latter space ventures, there is the reality that "tested" systems can fail, with similar results. This is particularly evidenced in the Apollo 13 flight where the "normal" mode of flight had to be aborted and the Grumman LEM used as a backup "life raft" system. This knowledge can be extremely stressful to crew members.

In addition, confinement with no possible means of vacating the environment, even for a short period of time, will add an additional measure of stress. For this reason, the internal environment of the habitat should not induce any further stress upon individual crew members or on the crew as a group.

One method of reducing any potentially additional stress is by configuring the environment in a manner that is familiar to the crew members. In a zero "g" environment, man has certain capabilities that should be utilized when designing the habitat. It is believed that, in the initial phases of the flight, such an environment might prove to be a greater source or amusement and entertainment than it can be a detriment. As the flight continues, and the stresses of confinement and isolation begin to summate, relief might be gained (to some degree) by providing the astronauts with "familiar" surroundings. These "familiar," "homey" features might help reduce the subjective and group stresses perceived.

## SPACE HABITATS SHOULD SUPPORT INDIVIDUAL AND GROUP EXPERIENCES AND ACTIVITIES

The environment within the habitat should enable the individual or the group to perform activities that are desirable for the maintenance of individual stability. Additionally, group activities that will foster cohesion within the group should be provided. The design of the habitat and the supplies therein should assist the individual growth of the astronaut, if this is desired. It should also be capable of "giving" such assistance to the group, if this is deemed desirable or necessary.

## SPACE HABITATS SHOULD BE ADAPTABLE, ALLOWING FOR AS MUCH VARIABILITY AS POSSIBLE

It is recognized that the space within future habitats will be restricted in terms of the size of various compartments. Since the area configurations in terms of walls and furnishings might be best suited for one particular activity, and not for another one that might be performed in the same general area, the crew members should have the ability to reconfigure the environment as they consider it necessary or desirable. This reconfiguration might take place as a function of the change of activities within the area, or the development of particular group processes over a period of time. By allowing this capability, the following can occur:

- Sleeping areas can be varied to allow for greater or lesser numbers of individuals to share a given compartment. This is performed by altering the total area allocated for this function, as well as by altering the internal configuration of the furnishings.

- An area can serve multiple purposes. Reconfigurations of the area can allow change from one function to another, depending on the needs of the crew members.

SPACE HABITATS SHOULD NOT HAVE STERILE LEVELS OF SENSORY STIMULATION

The results of sensory deprivation studies indicate that this condition can be debilitating to individuals. While a space habitat will not have sensory deprivation qualities in the experimental meaning of the term, it might have a minimal amount of sensory variability. Little is known about the effects that this condition might have on crew members' performance or psychological stability. From a review of the literature, however, it would appear that limited sensory stimulation levels is an undesirable characteristic for habitats. For this reason, it is considered desirable for the astronauts to be able to vary the level of sensory inputs available to them.

In the visual realm, the ability of the crew members to vary lighting intensity, area configuration and furnishings, are methods of varying visual stimulation. This should be available to the crew members to a limited degree since the lighting intensity desirable for sleeping, resting (socializing), and working conditions differs. Some variability to accommodate performance under these differing conditions must be made available to the crew members. In addition, the light intensity, "room" coloring and shading can be altered to combat visual/perceptual boredom.

Auditory stimulation levels can be varied in several ways. A crew member can leave one area to go to a more quiet or noisy environment. The movement away from or toward a sound source (within the same area) can also alter the sensory input level for this modality. This can be accomplished by "the closing of a door," or the movement of a chair to a new seating location within the confines of a room.

SPACE HABITATS SHOULD ALLOW FOR PRIVACY AND/OR SOCIAL INTERACTIONS WHEN EITHER OF THESE AREA DESIRED

While the habitat should allow for and enable social interactions, it is recognized that there will be times when the individual crew member(s) will desire privacy. The habitat should be designed to facilitate either of these behavior patterns. If the furnishings of an area are "portable," or movable, and if the area is of sufficient size, then an individual can isolate himself from other members of the group who might be in the area. This can be done while not leaving the group totally. In other instances, the individual might desire total privacy. In this case, he might be able to isolate himself by partitions, or by "cocooning" if he has a "private" sleeping area.

SPACE HABITATS SHOULD ALLOW FOR BOTH CASUAL AND MORE FORMALIZED SOCIAL CONTACTS

It is anticipated that normally, most individuals would use the "social" area of a habitat for casual interactions. This area would be desirable for use in more formalized activities initiated by the habitat commander or by specialized groups within the crew. By having movable furnishings (chairs, tables, etc.,) this area could be reconfigured to allow for both types of interactions. If a crew member was displaced by such a meeting, it would be desirable if another area of the habitat served his needs.

SPACE HABITATS SHOULD ALLOW FOR INDIVIDUAL AND GROUP NEED FULFILLING ACTIVITIES

By having a flexible environment, the crew members would be able to adapt the environment for individual recreational activities such as reading, etc., or for group activities such as card playing, darts, movies, etc. The need for the flexible environment extends to the furnishings in the "social" area, so that smaller tables can be joined in order to enable larger group activities, or separated to enable individual activities. The sleeping areas should also enable individual activities.

SPACE HABITATS SHOULD ALLOW FOR COMMUNICATIONS ON BOTH FORMAL AND INFORMAL LEVELS

This guideline is somewhat similar to that recommending flexibility to allow for casual and more formalized social contacts. Within formalized communication patterns, the ability to alter the environment would enable various levels of "rigidity" within the communication structure. Depending on the nature of the structure desired, the group might be able to form into such patterns as the classical "wheel" or "circle" arrangements studied in many laboratories.

The guidelines presented on this and previous pages suggest several general requirements for designing habitats for astronauts undertaking long duration missions. Each requirement will be presented on a separate page. Where possible, graphic presentations indicate the potential design features that will allow for implementation of the specific requirement.

## THE ABILITY TO RECONFIGURE PHYSICAL AREAS

The ability to reconfigure areas appears to be a primary requirement. This reconfiguration requirement applies to both personal and social areas. An example of the effects of reconfiguring of both personal and social areas can be seen in the accompanying figures. While these figures do not represent current NASA concepts, they are presented since they represent the concept of the ability to reconfigure an area, and demonstrate the impact this has on the habitat. These presentations represent spatial reconfiguration ability and are not representative of currently conceived spatial allocations.

The ability to reconfigure sleeping areas would allow for isolation if this is considered a desirable feature of "dormitory" areas. It would also allow for the grouping of two, three, or four crew members into an expanded, larger "sleeping" area. Such multiple dwelling arrangements might be required during periods of transition from one crew grouping to the next. (See Figure 10.)

The importance of this requirement cannot be overstressed. Numerous studies have indicated that proximity between individuals is most important in the development of interpersonal relationships. Festinger (1951) discovered this in his study of relationships that developed in a housing project at MIT. Bryne and Bouehler (1955) commented on the interaction capability/acquaintance and friendship development phenomena. They noted that students in neighboring seats were more likely to become better acquainted than those in seats that were more distant from one another. Walker and Guest (1952) noted this same relationship in workers in an industrial facility. Further evidence, most directly related to the present study, comes from Blake et al., (1956) who discovered that acquaintance volume was higher in closed cubicles than among the same men in open cubicles in an Air Force barracks. In the closed cubicles, more friends were selected from among the five others assigned to the same cubicle than from others in the barracks.

As can be seen in Figure 10 the use of modular furniture units and the use of movable partitions allows for great versatility in interior design and configuration. This representation depicts two individual sleep areas, as well as a two-man sleeping compartment. By retracting the movable partition, this space can be enlarged to accommodate more individuals or, conversely, the two-man unit can be divided further to allow for private areas. Due to the "0" gravity field, the modular units should be moved easily into desired locations.

This requirement would be useful in the social area as well. Reconfiguring areas (spatially) allows for more optimum multiple use of space by allowing for segmentation of the area to meet the needs of various individuals/groups at specific time periods.

Figure 10. Single and Multiple Sleep Areas

## THE ENVIRONMENT SHOULD BE FLEXIBLE

This concept implies more than just changeable spatial configurations (changing of the sizes of areas), it suggests that the internal furnishings should also be variable. As was noted in the presentation of the guidelines a flexible capability with regard to the furnishing of an area allows for:

- separation of a crew member from the group (if he so desires) without isolation from them,
- facilitation of multiple uses of an area,
- alteration of "private" quarters in order to facilitate changing needs of crew members.

This capability can be seen in a number of the figures presented in this section.

In the crew members' sleeping area, the reconfiguration of the internal furnishings will allow for the individuality and territoriality noted in other habitats. This is accomplished by allowing the crew member to introduce "personalized" artifacts into the environment, and to arrange these in a manner satisfactory to the individual.

Figure 11 represents a hypothetical sleeping area that is amenable to reconfiguration. The modular sleep unit consists of a Murphy bed that can be opened for sleep, or used as a couch when more than one person is in the unit. The face of the storage area (dresser) can be lowered, or extended to provide the individual with desk space. An inflatable chair can be used when more than one person is in the unit, or it can be stored when more "private" space is required. Shelves in the storage unit allow for individual arrangements and display of personal belongings desired. Further modification to this area could be initiated by relocating the sleeping unit along either of the "side" walls (movable partitions). It is recognized that these are concepts, however, they appear to be feasible and do meet the goal of this requirement.

The social area requires an internal environment that is flexible. The concept of multiple use of specific areas requires that these areas be reconfigured for differing uses. The arrangement of seating patterns will differ if the crew members are engaged in movie viewing, discussing operations of the habitat, or small group recreation. If the same area is to be used for exercising the area would once again require reconfiguration. (See Figures 12 and 13).

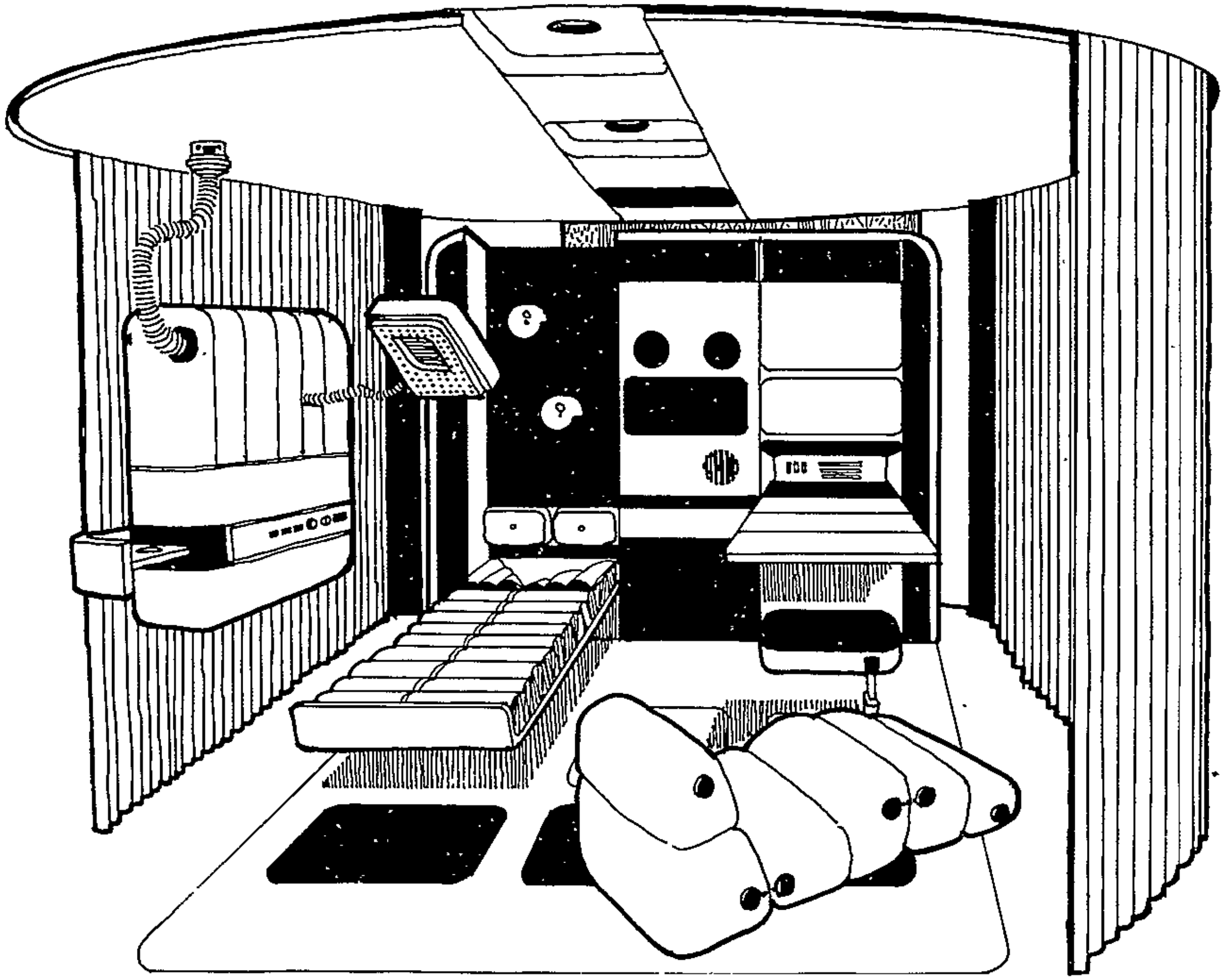

Figure 11. Individual Sleep Area

## THE ASTRONAUTS SHOULD BE CAPABLE OF VARYING CERTAIN STIMULUS PARAMETERS

This requirement will enable the astronauts to combat the effects of stimulus monotony which can summate and produce, over time, debilitating reactions in crew personnel. As noted earlier the areas most amenable to stimulus change are the visual and auditory areas. For this reason, changeable visual and auditory characteristics of the habitat are presented in the following diagrams. While these diagrams do not indicate the color potentials fully, the importance of color must be recognized. By using multiple colored panels (one color one side, and a different color on the opposite side), the astronauts will be capable of altering the color scheme of specific areas. This requires movable wall panels. Similar effects can be obtained by the use of colored lighting. In this case, the walls would be white and the changing lighting would produce varied colors and tonal qualities in the surrounds. These effects would also vary the lighting intensities of the environment.

Numerous studies dealing with sensory deprivation have indicated the debilitating effects of this phenomena. It must be stated that the environment of proposed long-term space habitats is not one inducing sensory deprivation. It might, however, be considered a visually and auditorily sterile environment. Since vision is one of man's most used senses, personnel involved in the design of space habitats should enhance the visual stimulus properties of the habitats. One method would be to use various colors in different portions of the habitat. This means that, not only should walls be presented in different colors, but that habitat implements such as chairs and other fixtures, should also vary in color. This has the ability of presenting visual stimulation and, to some degree, psychological well being.

Since the habitats are limited in their space capabilities, the use of color can enhance size estimations and hence, apparent depth. By coordinating appropriate colors for walls and furnishings, a room can be made to appear larger than it really is. This should be undertaken in proposed habitats.

The habitat must allow for generalized ambient lighting and localized lighting sources. While the light intensity required for card games (in the social area) might be the intensity for the general area, a person reading or performing some hobby task would, most likely, require increased lighting intensity. This should be available to the crew members.

Figure 12 indicates the flexibility recommended in illumination of rooms in proposed habitats. The use of selected lighting allows for the multiple use of an area, as well as the potential (partial) for withdrawal from group activities without forced isolation of an individual.

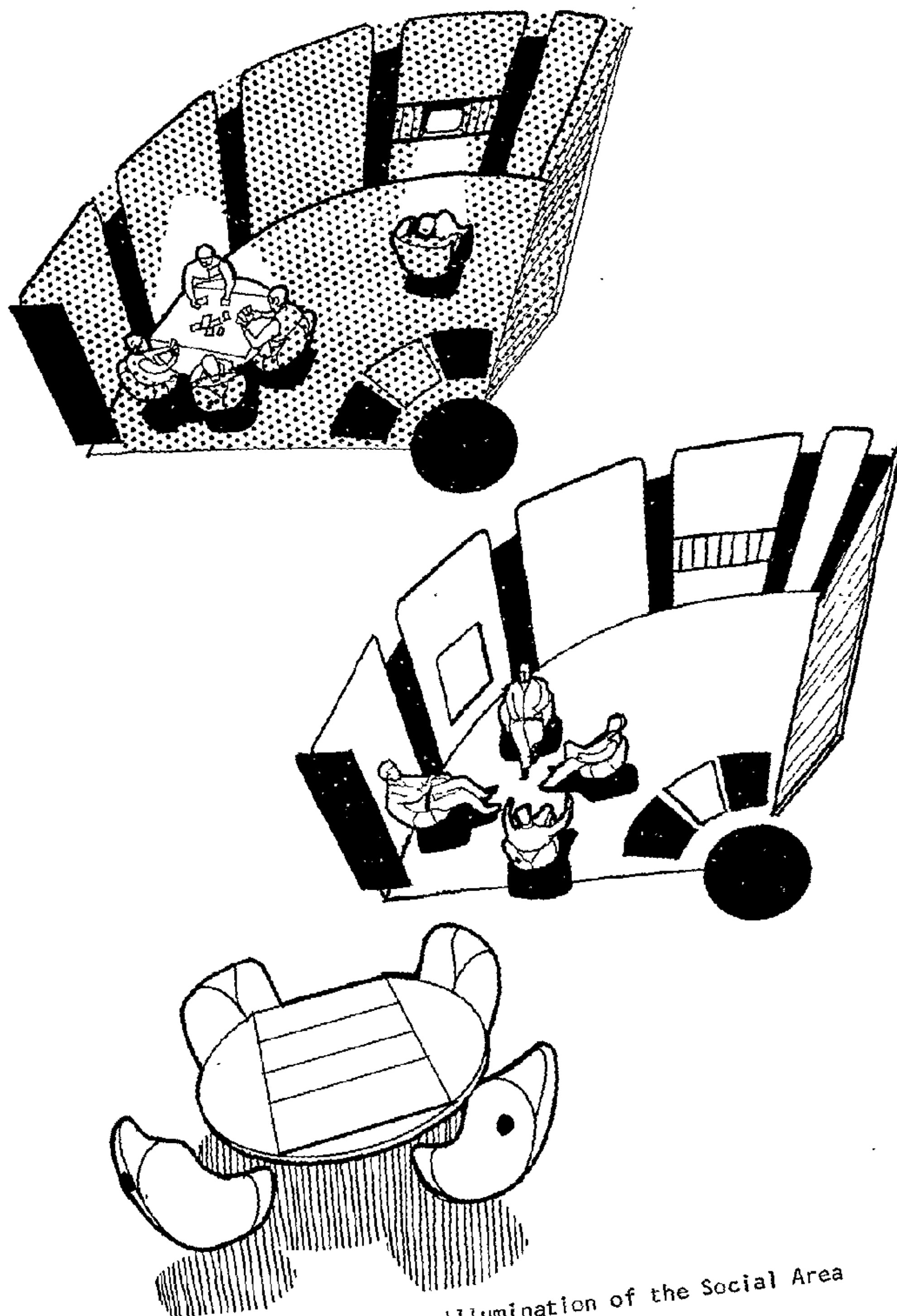

Figure 12. Illumination of the Social Area

THE ENVIRONMENT SHOULD ALLOW FOR A VARIETY OF ACTIVITIES PER AREA

While this is an extension of several requirements listed earlier (the ability to reconfigure physical areas and the environment should be flexible), it has an entity unto itself. The requirement for multiple use of areas necessitates that material required for any of the uses of the area be present or located in close physical proximity. This will require a detailed analysis of the uses to which areas might be put. An example can be provided by the sleeping areas of the habitat. The literature indicates that individuals under the conditions of long-term confinement and isolation tend to withdraw from social interactions. The sleeping quarters should allow for its prime function of sleeping. In addition, it should facilitate inhabitant behaviors such as reading, individual recreation, and two-man activities such as studying, card playing, etc. It might well serve as the area from which inhabitants can communicate with loved ones while in the terrestrial environment.

The social area might be used for group recreational activities, meetings, and exercise requirements. The location and storage of materials that facilitate these activities will strain design concepts but storage, and potential arrangements for these activities must be considered and accounted for in the final design of the habitat. For maximum multiple usage of an area, it must be capable of being reconfigured rapidly, and with a minimum of effort.

Figure 13 indicates the potential for multiple use of the social area due to the modular design of furnishings, as well as the use of a movable partition. It is only representative of potential design practices for the multiple use of an area.

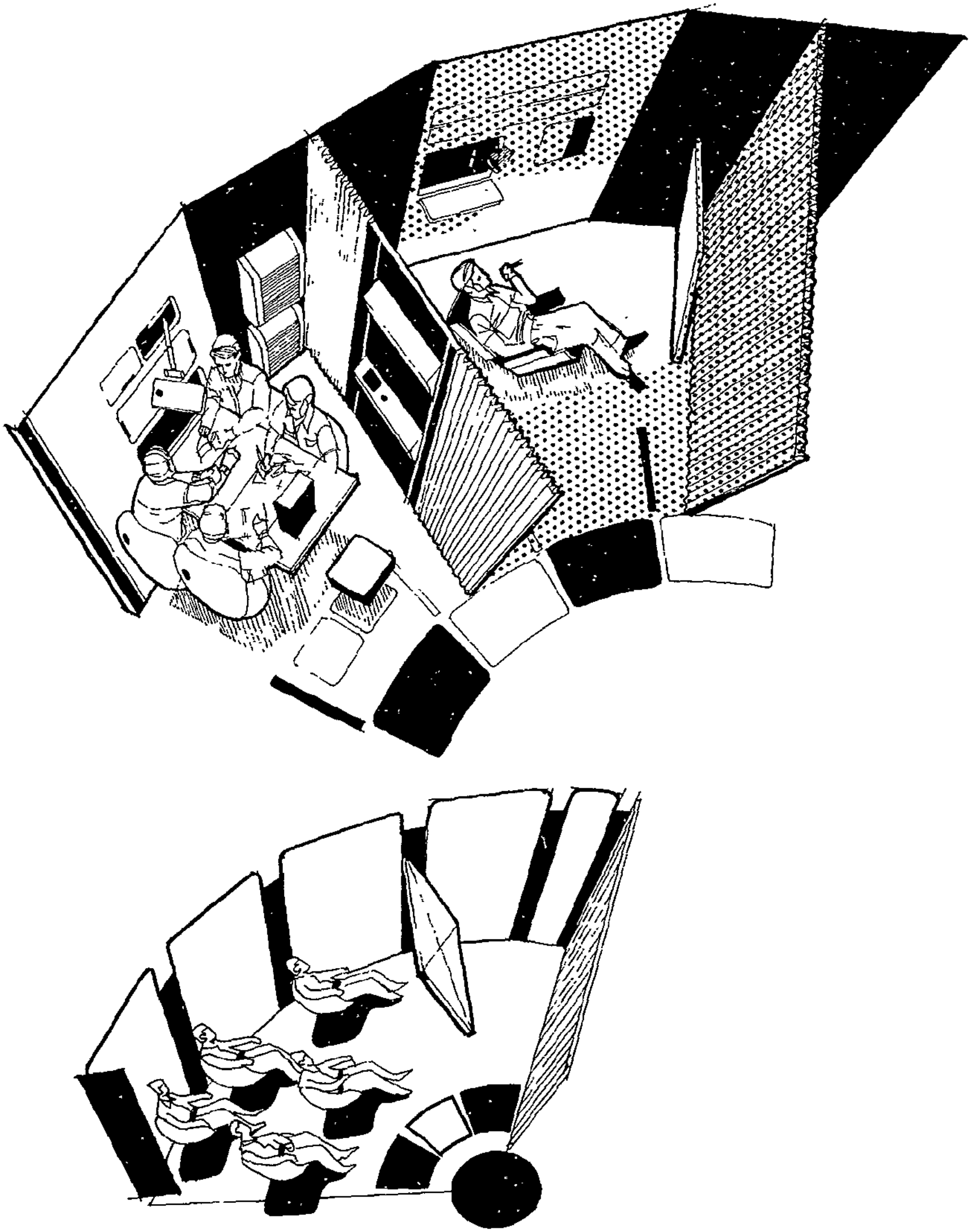

FIGURE 13. Multiple Use in the Social Area

## ANY HABITAT MUST SATISFY GENERAL PHYSIOLOGICAL REQUIREMENTS (EC/LS)

It is self-evident that the safety of crew members is a prime requirement of any habitat. This necessitates that the habitat supplies all of the EC/LS requirements of all crew members. In the design of the habitat, partial control of these functions should be under the control of the crew members. Such control functions might include temperature control, air flow, etc.

An additional area that requires further study and definition concerns the maintenance of physiological conditioning of the crew members. Equipment and exercise techniques must be developed in this area and incorporated into the design of the habitat. It is desirable for these activities to be pleasant (enjoyable) and of a nature that requires a minimum amount of external motivation for crew member participation.

Figure 14 represents a designer's conception of a potential exercise module for future space crews. In such an area, the requirement for increased ventilation and temperature control becomes most evident. Individuals exercising typically have higher metabolic rates, as well as an increased thermal output. This, plus the need to remove body odors, requires increased air flow to "wash out" the room. If the same area were to be used as the social area during a different temporal period, the air flow and temperature requirements would vary under the differing conditions of use. For this reason, crew personnel should be capable of selecting the desired "environmental" conditions required for specific activities.

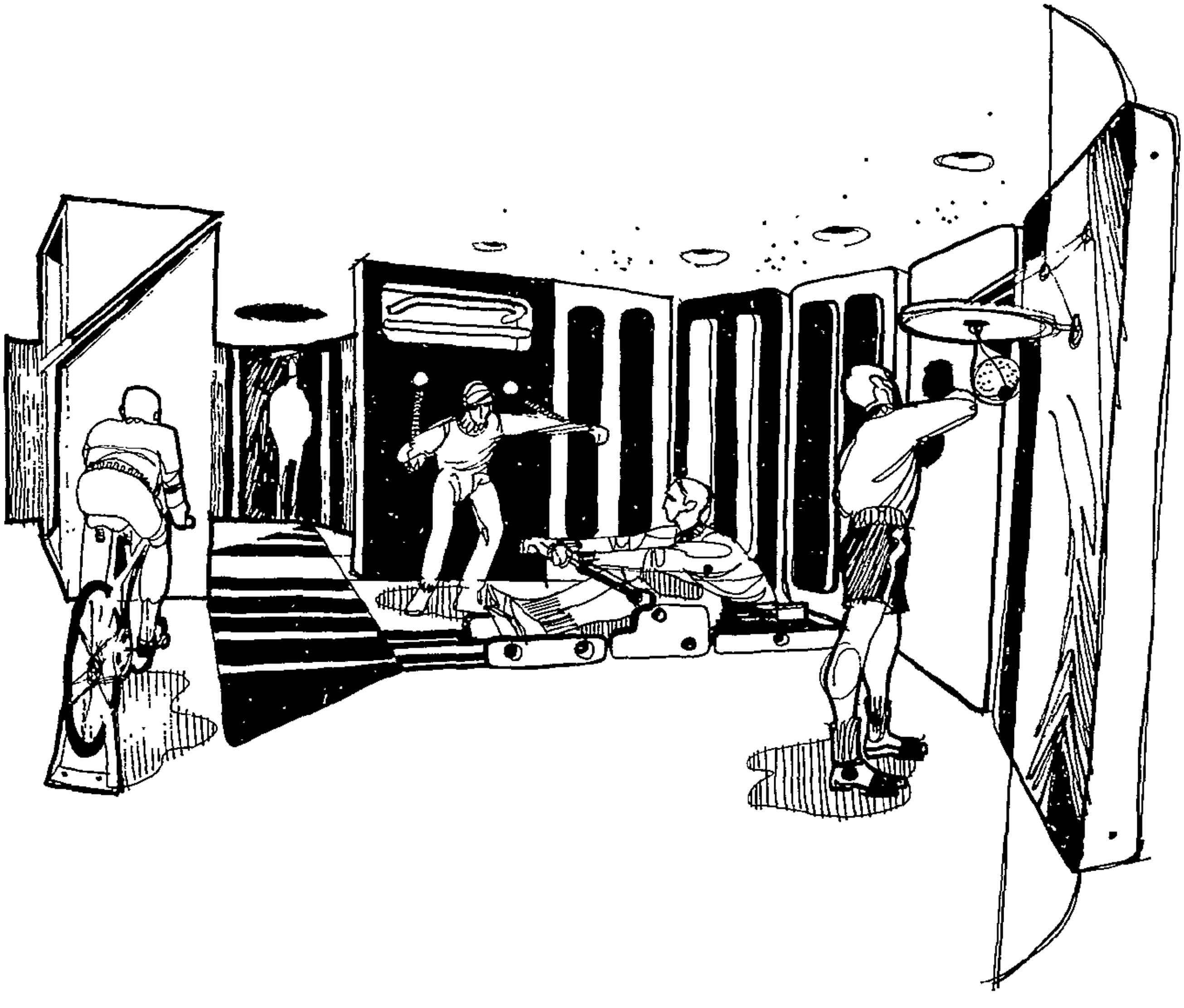

Figure 14. Crew Exercise Configuration

## LARGER AREAS IN HABITATS SHOULD ALLOW FOR INDIVIDUAL USE AS WELL AS GROUP USE. INDIVIDUALS SHOULD NOT BE FORCED INTO INTERPERSONAL CONTACT IF THIS IS NOT DESIRED

Excessive rigidity in the internal design of a habitat might force individual crew members into situations where they must join in the activity of others, or isolate themselves from such activities by "cocooning" in private quarters. In many instances, these crew members might desire a "middle of the road" approach, that is, to be a non-participating observer of group activities. As was noted earlier, a flexible environment (walls and furniture) will allow for such individualized behaviors. This is particularly true when considering the social area of the habitat. By reconfiguring the furniture arrangement, and varying the lighting intensity of specific areas of the room, it is possible to allow the crew members "privacy" while they are still members of the larger group. (See Figure 12.) It is believed that this ability is more desirable than forcing the individual from the location into isolated surroundings. By being present, the individual may become interested in the activities, and after a short period, join in them. If this does not occur, he might join or initiate other activities of interest to himself and, possibly, others. The more exposure the individuals have with other crew members the greater the potential for friendships to be established. While the formation of cliques can be disruptive to the organization and discipline required in these habitats, friendships between various crew members can assist in the development of cohesiveness of the group. The greater the exposure of crew members to one another, the greater the potential for such cohesive bondings to be formed.

Figure 15 indicates how this requirement might be implemented around a social/nutritional area. The use of movable partitions allows for the division of the total area into a game room, a separate hobby area, as well as an all-purpose social/nutritional area. Even greater flexibility is produced by the use of expandable/interlocking furniture, such as the table. In this figure it is shown in an expanded, interlocked mode. This is desirable for large group "work" meetings, or group dining. By separating the table, smaller work groups or dining areas might be formed. Once again, this flexibility is considered to be desirable.

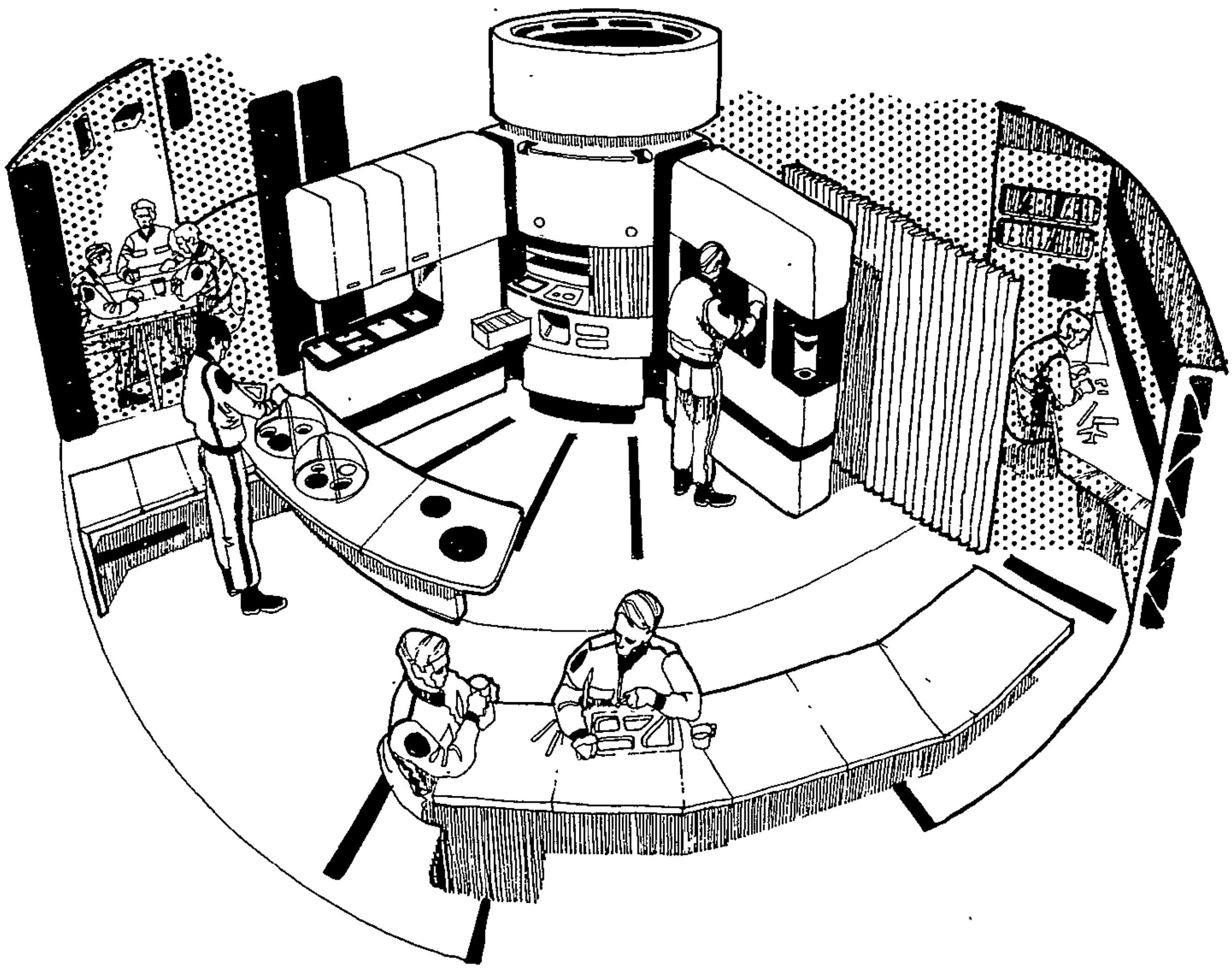

Figure 15. Flexible Social/Nutritional Area

## HABITAT DESIGNS SHOULD ALLOW FOR THE DISSIPATION OF IRRITABILITY (AGGRESSION) IF THIS BECOMES BOTHERSOME TO CREW MEMBERS

A review of the literature indicates that isolated and confined groups in the terrestrial environment tend to suppress hostile feelings towards other individuals in the group. This is done in order to maintain a semblance of group stability. It is believed that designers and NASA personnel interested in recreational and physical conditioning activities can incorporate these activities so that they can serve to dissipate aggression. This might necessitate the design of more strenuous activities which allow crew members to "work off steam." The desirability of this requirement can be seen in the clinical literature. Persons capable of shedding aggressive feelings tend to perform allotted tasks with greater efficiency over longer periods of time. The dissipation of these feelings will also reduce the possibility that "cross currents" are established between various group members. Such a reduction will be beneficial to the development and maintenance of stability within the group.

An additional method for dissipating hostility or channeling aggressive feelings towards constructive goals is via "rap" sessions between the groups or individuals concerned. Here, the environment should support the formation of such group sessions. Particular activities would depend upon the design of the habitat as well as the skill of the leader in conducting such sessions. It is believed that either or both of these methods (see Figure 16) would be beneficial to group stability and individual performances, over extended periods of time.

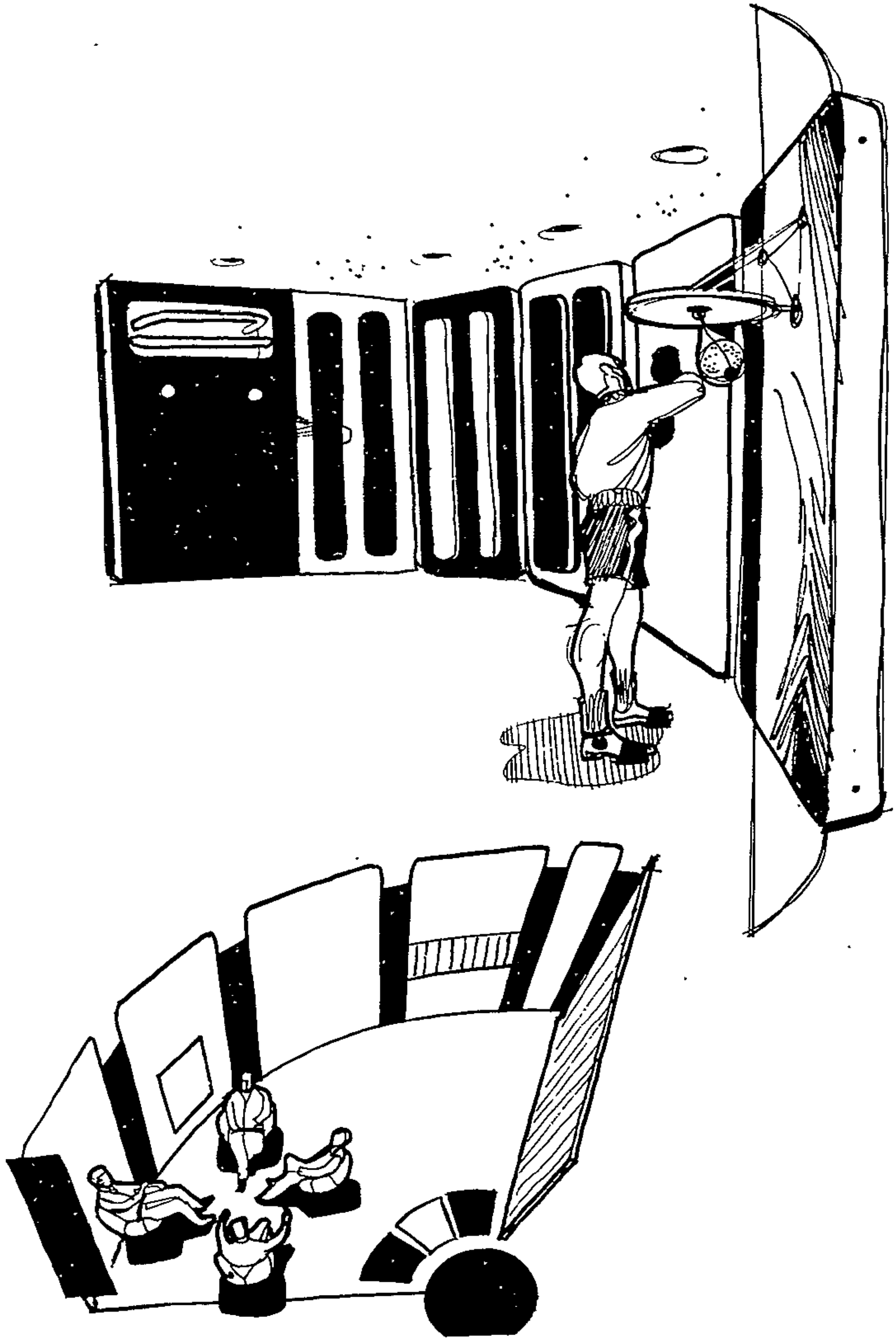

Figure 16. Social Area

SPACE HABITATS SHOULD REPLICATE AS CLOSELY AS POSSIBLE THE ENVIRONMENTS FOUND IN THE ASTRONAUTS "NORMAL" ENVIRONMENTS

It was noted earlier that the design of "normal" environments is desirable for individual as well as group stability. Each crew member will be under a great deal of stress, and the "normal" environment might assist in reducing the tensions produced under these stress conditions. Any such reduction would assist the stability of the group itself. Consideration must be given to sitting and sleeping positions, and the hardware required for accomplishing these functions. The interactive effects of a zero gravity and the psychological well-being produced by familiar objects, must be evaluated and considered in the design process.

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